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ABSTRACT

Prepared by energy experts and educators to introduce middle school and high school students to natural gas and its role in our society, this kit is designed to be incorporated into existing science and social studies curricula. The materials and activities focus on the origin, discovery, production, delivery, and use of natural gas. The role of energy in our society is examined, and students are challenged to consider their role in America's energy future. Materials included in this kit are: (1) a teacher's guide which provides instructions for the use of the materials, basic information on natural gas, suggested supplemental projects, a glossary, and suggested resources for additional information; (2) a booklet, "Natural Gas Energy," that can be used as a reference source or a classroom text; (3) four copy masters to be reproduced for students which contain information and activities on the natural gas system, products of the natural gas well and their uses, the economics of natural gas, and careers in the natural gas industry; and (4) a two-part overhead transparency set that is the basic teaching aid for discussing the relationship of energy use to our nation's history. An educator's survey is included for evaluating the usefulness of the materials. (EM)

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Natural Gas Energy Educational Kit

American Gas Association
Educational Programs Division
1982

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

American Gas Association

1515 Wilson Boulevard, Arlington, Va. 22209
Telephone (703) 841-8400

George H. Lawrence
President

Dear Educator:

Thank you for selecting the new Natural Gas Energy Educational Kit for use in your class. We hope you and your students will find it informative and interesting.

This package offers instructional materials and activities that focus on the origins, discovery, production, delivery and use of natural gas, our nation's largest domestically produced source of energy. The materials also examine the role of energy in our society. and challenge students to consider their role in our energy future. All of the materials have been designed with the help of educators to fit into current science and social studies curricula.

We in the natural gas industry are proud of this package as an addition to our continuing commitment to energy education. This kit is based on a comprehensive exhibit on gas energy that was featured at the 1982 World's Fair on Energy held in Knoxville, Tennessee. That display is now housed permanently in the Museum of Science and Industry in Chicago.

After you have used the kit, we would appreciate some word from you on your experience and your ideas on future programs and materials we can provide. Enclosed is a postage-paid response form for your convenience.

If you have any questions about this kit, natural gas, or energy in general, please feel free to contact the Educational Programs Division of the American Gas Association, 1515 Wilson Boulevard, Arlington, VA 22209.

Sincerely,

George H. Lawrence
President

TEACHER'S GUIDE

Introduction

The Natural Gas Energy Educational Kit has been prepared by energy experts and educators to introduce middle school and high school students to natural gas and its role in our society. This kit offers instructional materials and activities that focus on the origin, discovery, production, delivery and use of natural gas, our nation's largest domestically produced source of energy. The kit's materials also examine the role of energy in our society, and challenge students to consider their role in our energy future.

The elements of this kit are: (1) a classroom poster that presents the most important points in summary form; (2) the booklet **Natural Gas Energy** that can be used as a reference source or a classroom text; (3) a two-part overhead transparency set that is the basic teaching aid for discussing the relationship of energy use to our nation's history; (4) four copy masters that cover the key points of the text and present recommended student activities; and, (5) this teacher's guide which includes instructions for the use of all the materials, basic information on natural gas, suggestions for supplemental projects, a glossary and suggested sources for additional information.

About This Kit

The Natural Gas Energy Educational Kit is based upon an educational exhibit that was featured at the 1982 World's Fair on Energy held in Knoxville, Tennessee. That exhibit is now housed permanently in the Museum of Science and Industry in Chicago.

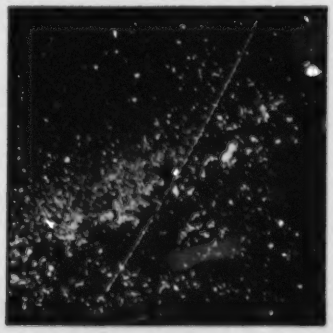
Energy Principles

In all the universe, there exists only matter and energy. Matter is composed of molecules and takes up space. Energy is the ability to do work, to exert a force on matter.

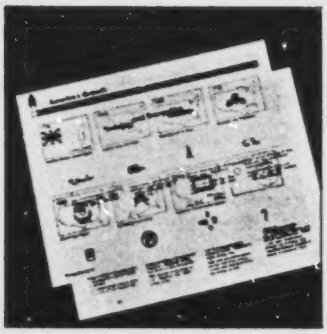
Energy cannot be created or destroyed, but it can change from one form, such as heat, to another, such as motion. Machines are used to make this conversion.

Matter can also change states –from solid, to liquid, to gas– under certain circumstances. When matter changes states, energy is released.

All the energy we know about comes from either the sun or from the splitting of atoms of certain molecules (nuclear energy).



Energy And Our Society



An important lesson of this kit is the relationship of energy and our nation's history. A two-part overhead transparency set illustrates this relationship and encourages students to consider what energy choices lie ahead.

The first part, "America's Growth...," tracks our history and points out economic, political and social conditions.

1776–The 13 colonies declared independence from Britain. There were about 4 million Americans, only a third of whom supported independence.

1840–The United States now stretched beyond the Mississippi River. The push to the West was underway and in the East differences between North and South increased.

1890–The Manifest Destiny was realized as the nation reached from the Atlantic to the Pacific, linked by telegraph and railroad lines. Immigrants from Europe and Asia arrived in waves.

1910–Henry Ford's horseless carriage led the way for a rush of mass-produced consumer goods. Prosperity before the First World War.

1945–At the end of the Second World War, the United States was the world's political and economic leader. The Atomic Age had begun.

1973–Landings on the moon by U.S. astronauts had become almost routine. The Vietnam War was drawing to a close.

Today–Now there are over 230 million Americans. The United States continues its economic pre-eminence, although there are some challenges in productivity and technology.

Future–Here, students could be called upon to predict events.

The second part of the transparency set, "...and Energy Use," is designed to lay on top of the first. It identifies some of the economic and energy conditions of the same years. By keeping the first part on the screen, students will be able to understand the relationship of the many factors involved.

1776–The economy was agricultural, small farms and small towns. Energy came from the labor of people and animals. Wood was just about the only fuel.

1840–While still a primarily agricultural nation, small factories were operating in New England. Most were powered by running water. Wood was about 90 percent of the fuel source.

1890–Immigrants increased the population rapidly, particularly in the cities. Railroads and telegraph lines linked all parts of the nation. Extensive rail lines made it possible to move coal from mines to factories, so the Age of Coal began. About this time, natural gas and oil wells were first drilled, and Thomas Edison had a practical electric light bulb.

1910–The Model T Ford proved the value of the assembly line. This let loose a flood of demand for consumer products, mostly energy-consuming devices. Coal continued to be the dominant energy source, supplying nearly 80 percent of our energy.

1945–Pent-up consumer demand, particularly for housing, appliances and cars, led a massive economic boom. Oil became the predominant energy source and the atom offered the hope for unlimited and inexpensive electricity. For the first time, the United States used more oil than it produced and started importing oil from the Middle East.

1973–The Arab members of OPEC declared an oil embargo on the United States. This resulted in gasoline lines and much higher energy prices. The federal government adopted a policy of encouraging and, at times, mandating energy conservation.

Today–The United States maintains its overwhelming economic advantage. It now uses a third of the world's energy for only a sixth of the world's population. But it also produces food, goods and materials for export far in excess of its population. Energy prices have stabilized somewhat, but have enforced real energy conservation and an increased realization of the need to develop our own energy resources. Still, about half our oil is imported–about the same percentage as 10 years ago.

Future–We will rely upon technology to further reduce imported oil use, increase our domestic supplies of energy and find new ways to use what energy we have more efficiently. Natural gas, a predominantly domestic energy source, is a key element in our energy future.

Student Project Masters

This kit includes four copy masters that present information and suggested activities for the class. These sheets are to be retained by the students.

Project 1:

The Natural Gas System

Objective: To be a primer on the natural gas industry–how gas is produced, how it gets from well to user, and the ways we use natural gas.

Discussion: We suggest you distribute this at the beginning of the unit. It provides basic information and complements the poster and the transparency lesson.

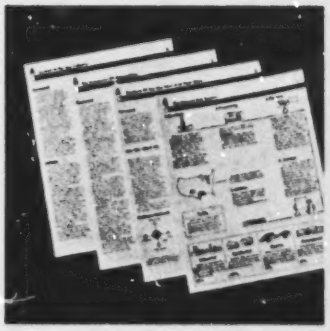
Questions:

- How does natural gas get from well to users?
  Through a million-mile network of underground pipes.
- What part of our economy uses the most natural gas?
  The industrial section.

Suggested Activity: Students are directed to draw a map of the route of the natural gas transmission line that services their community. This is an assignment you could give a small group who would produce the map and present it to the class.

Project 2:

Products Of The Natural Gas Well And Their Uses



Objective: To introduce the concept of combustion and the chemistry of natural gas, and to explain that many things are made from and with natural gas.

Discussion: When methane (the chief component of natural gas) burns, its atoms are rearranged to form different compounds and energy is released. The main point to note is that energy is released when matter changes from one form (methane and oxygen) to another (water and carbon dioxide) during combustion.

Most of the natural gas we use goes to providing heat for homes, businesses and industry, and for generating electricity.

The chemistry of natural gas is also important. First, a variety of fuels are by-products of raw natural gas. Second, other substances in raw natural gas have scientific and pharmaceutical uses. Third, the chemicals of raw natural gas can be used to produce a variety of products.

Questions:

- When methane burns, what is released?
  Water, carbon dioxide and energy.
- What atoms make up a molecule of methane?
  One carbon atom and four hydrogen atoms.

Suggested Activities: Students are directed to find out the role of natural gas in their community's industrial (manufacturing) and/or commercial (office buildings, stores and restaurants) sector and report back to the class. In addition, some students can compare the chemical composition of coal, oil and natural gas to determine which fuel burns with the least pollution. (Note: The chemistry of oil and coal is extremely complex. For the purposes of this exercise, a listing of the basic chemicals of each should suffice.)

Natural Gas Energy Poster

Project 3:

The Economics Of Natural Gas

Objective: To explain the role of the private sector and the public sector in providing energy in our society, and the responsibility of federal, state and local governments in determining customers' natural gas rates.

Discussion: A diagram shows that the public (voters and consumers) is involved in the economic process that brings natural gas to the marketplace. Federal government agencies regulate the companies that drill for natural gas and those that transport natural gas across state lines. State and local government agencies regulate the local gas companies, setting the rates to be paid by consumers for natural gas service. Emphasis is on the interdependence of the private and public sectors in our economy.

Questions:

- What sector in our economy produces, transports and delivers natural gas?

  The private sector– individual companies operating for a profit. Because natural gas is so important to our economy, private gas companies are regulated by government bodies.

- Who regulates the prices gas producers can charge gas transmission companies?

  The Federal Energy Regulatory Commission, an agency appointed by the President with the consent of Congress.

- Who regulates the prices local gas companies charge users of natural gas?

  The state's public utility commission, which is appointed by the governor and the state legislature. (Note: In some cities, this function is handled by a municipal agency or the city council. In some states, the public utility commission is elected.)

Suggested Activity: Students are directed to find out how gas prices are regulated in your state or city and to redraw the diagram to show local titles.

Project 4:

Careers In The Natural Gas Industry

Objective: To encourage consideration of career choices; how to prepare for that career; and, to prepare students to handle job applications and interviews.

Discussion: This activity encourages students to look at their own skills and interests and then apply those to the job market. A listing of a few positions (some requiring college education, others not) is given, but it is only a starting point for classroom discussion.

A sample application is presented and students are directed to complete it, using as their job choice either one listed or one that has already been selected. Neatness, completeness and the ability to clearly and briefly state skills and experiences should be emphasized.

Questions:

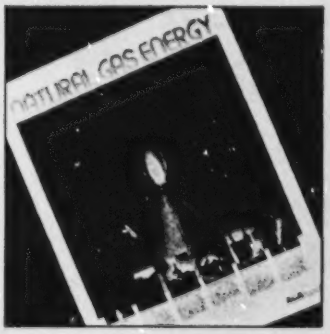
Career decisions do not lend themselves to questions that can be answered correctly or incorrectly, however, the subject does offer an opportunity for a classroom discussion about how a student's skills and interests should be an important career consideration:

- Occupations in the natural gas industry include people working (1) with machines, (2) with data, or (3) with people. Which best suits your personality? What are examples of each type of job? What pressures and rewards are there for each type? (Hint: Make a table of the three job types and examples of each on the blackboard during this discussion.)

Suggested Activities: Students are directed to use the school library to learn more about jobs. A classroom discussion about careers with the school's guidance counselor and/or the personnel officer of the local gas company is suggested. Independent investigation of a particular job by interviewing someone with that job is suggested. A final classroom discussion focuses on the effects of technology on job choices.

Included in this kit is a classroom poster. You may want to put it up a few days prior to the beginning of the lesson to allow students a chance to familiarize themselves with some of the basic points to be discussed.

The poster follows the format of the enclosed booklet, **Natural Gas Energy**, and introduces concepts you may want to review with the class: chemical and molecular composition, energy, formation of the planet, the scientific method of gathering, evaluating and testing data, and energy conservation.



Natural Gas Glossary

Atom: The smallest particle of an element which contains all of its physical and chemical properties. Atoms combine to form molecules.

Biomass: Organic matter, especially plants. Biomass can be converted to fuel.

British Thermal Unit (Btu): A standard measure of heat energy. One Btu is the quantity of heat that must be added to one pound of water to raise the temperature one degree Fahrenheit. One Btu is approximately the amount of heat energy released in the burning of a kitchen match.

Charter: A license by a local or state government to a public utility such as a local natural gas company that allows the utility to provide service exclusively to a certain area, and requires the utility to operate in the public interest.

Christmas Tree: An assembly of valves and gauges at the top of a natural gas well that regulates the flow of gas from that well.

Coal Gasification: The process of converting coal to a gas similar in composition and use to natural gas.

Combustion: Burning. Combining a substance with oxygen to release energy in the form of heat and light.

Compression: Moving natural gas by increasing pressure on it to force its molecules closer together. Gas moves from areas of high pressure to areas of lower pressure. Compressor stations move natural gas through pipelines by this process.

Energy: The ability to do work, to exert a force on matter. Energy exists in different forms, such as heat, gravitational, chemical, mechanical, radiant, nuclear and sound. The sun and the nucleus are our two basic sources of energy.

Fossil Fuels: Coal, oil and natural gas originating from once-living plant and animal life now buried in the earth. When burned, fossil fuels release energy.

Gas: A state of matter that has neither independent shape nor volume. Other states of matter are liquid and solid.

Hydrocarbons: Compounds composed primarily of carbon and hydrogen. Natural gas, coal and oil are all hydrocarbons.

Liquefied Natural Gas (LNG): Natural gas that has been changed into a liquid by cooling to about −260 degrees F. (−160 degrees C) at which point it occupies about 1/600th of its gaseous volume.

Matter: Anything that is a solid, liquid or gas. When matter changes from one state to another, energy is released.

Methane: The chief component of natural gas. CH_4. A colorless, odorless, flammable, gaseous hydrocarbon. Methane can be obtained from a variety of abundant and renewable sources.

Natural Gas: A gas fuel found in porous rock formations beneath the earth's surface. Its principal constituent is methane (CH_4).

Public Utility Commissions: State government agencies that regulate all utilities, including local natural gas companies. Some states have different names for this body.

Quad: One quadrillion Btu, about the amount of energy a city the size of Boston or San Francisco uses in a year. The United States uses about 20 quads of energy a year.

Regulation: The process by which the public sector oversees the actions of the private sector in our economy. All sources of energy, except solar, are regulated by various government agencies. In exchange for the right to provide service exclusively in a certain area, utilities allow government agencies to establish the rates consumers pay for the service. The utility has the responsibility to provide good and reliable service at a fair price, while the government agency has the responsibility to ensure that the utility earns enough money to cover the cost of service and compensate its investors.

Tcf: Trillion cubic feet. The standard unit of measure for large quantities of natural gas. The United States produces about 20 Tcf of natural gas a year.

Therm: 100 cubic feet of natural gas. The equivalent of 100,000 Btu of heat energy. Consumer natural gas bills are usually stated in therms.

For More Information

Additional information about energy can be obtained from your school library. A review of articles in encyclopedias is a good place to start for basic information. Then check the Reader's Guide to locate recent magazine articles about energy. National Geographic magazine has published an outstanding series of energy articles over the past few years. One very good general reference book is **The Energy Fact Book** by Richard C. Dorf (an Energy Learning Systems Book by McGraw-Hill Book Co., 1981).

Your local gas company is your best source of information about natural gas. Most local gas companies have speakers, films and publications available free for the asking. Contact the company's Educational Representative, its Consumer Affairs Department or its Public Relations Department.

Natural gas energy education materials are also available from the American Gas Association. One of the best is a 13-minute film, **Natural Gas in the '80s.** Other good materials are A.G.A.'s Energy Reports on a variety of subjects. For more information on what materials are available, contact: Education Programs Division, American Gas Association, 1515 Wilson Boulevard, Arlington, VA 22209.

This Natural Gas Energy Educational Kit was written and produced by The JN Company for the Educational Programs Division of the American Gas Association.

AGA American Gas Association

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Gas Facts For Teachers

AGA American Gas Association

Natural gas is the single largest source of energy for homes, businesses and industry in the United States. It supplies about 27 percent of all the energy we use, and is America's largest domestically produced energy source. (Oil provides more energy, but nearly half of it is imported.)

As important as natural gas is–over 160 million Americans rely upon it directly and all of us use products made from or with natural gas–few of us really give it much thought. Before using this kit with your students, you might want to review these facts about natural gas.

What Natural Gas Is

Natural gas is an odorless, colorless flammable vapor composed chiefly of methane (CH_4), a combination of hydrogen and carbon. When natural gas burns it releases heat energy. Our supplies of natural gas will last well into the future, and the technology is being developed to produce methane from a variety of renewable sources.

Formation

Most scientists believe that natural gas is the product of the decay of plants and animals over millions of years. Natural gas was formed much the same way coal and oil were formed. Coal, oil and natural gas are all fossil fuels.

Finding Natural Gas

Natural gas is trapped in underground rock formations. Geologists use measuring equipment to locate gas-bearing formations, but the only way to be certain natural gas is in a particular location is to drill a test well.

Drilling For Natural Gas

Most natural gas we use comes from wells drilled in the lower 48 states or in the Gulf of Mexico. The first natural gas well, drilled in 1821, was very shallow. Today wells are as deep as 5 miles and are drilled by rotary rigs.

Processing Natural Gas

From the well, raw natural gas is first transported to a processing station where water and chemicals are removed. Some of the by-products of this raw natural gas are used by industry as special fuels, and some are used in the manufacturing and pharmaceuticals industries.

Transporting Natural Gas

From the processing plant, natural gas moves to consumers through underground pipes that reach into every region of the country. This nationwide pipeline system is over 1 million miles long. It is the most efficient fuel delivery system devised.

Compression and Storage

Natural gas moves through the pipeline by a process called compression. Powerful compressors located along the pipeline route push gas at a rate of about 15 miles an hour. Because we use more natural gas in winter than in summer, gas is produced and stored during periods of low demand for use when demand increases. In some places, gas is converted to a liquid and stored in special tanks. In other places, empty underground gas fields are used to hold gas.

Delivering Natural Gas

From the pipelines and storage areas, natural gas is fed to the local gas company, which adds an odorant to the gas for safety reasons. Then the gas is fed to consumers through smaller pipes that run to individual gas meters. The meters measure the flow of gas.

Use of Natural Gas

The chief role of natural gas is to provide heat energy in homes, factories and offices. The chemicals of natural gas (mainly carbon and hydrogen) also are combined with other substances to produce thousands of materials. The industrial sector accounts for 40 percent of our natural gas use, generating electricity takes 19 percent, 12 percent goes to offices and restaurants, and 29 percent goes to the residential sector.

New Technologies

More efficient gas appliances and equipment are being developed. New technology also is being used to develop additional sources of natural gas or methane from a variety of areas. Drilling wells deeper and in regions previously unexplored, extracting methane from shale and tight sands, importing gas by pipeline from Canada and Mexico and as a liquid by ship from overseas, and connecting Alaskan gas fields to the rest of the nation will help ensure gas supplies well into the future.

Methane From Other Sources

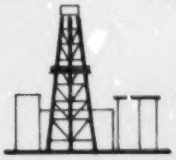
Methane also can be extracted from readily available and, in some cases, renewable sources. Work is underway in North Dakota on a plant to convert coal to energy-rich gas. A similar process could be used with peat. Methane also is the product of the decomposition of organic material in landfills. Converting biomass (plant and animal life) to methane through bacterial digestion also is possible.

Details on all these subjects are in the enclosed booklet, **Natural Gas Energy.**

STUDENT PROJECT MASTERS

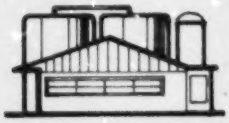
Four Copy Masters

1. Gas Wells



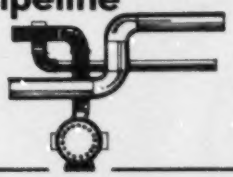
Natural gas, which is chiefly methane, is trapped in underground rock formations. Finding where gas might be located is a risky and expensive venture. Once a potential gas-bearing area is located, rotary rigs are used to drill through the rock– sometimes up to 5 miles deep – to release the natural gas. Most of our natural gas comes from wells drilled in the lower 48 states or in the Gulf of Mexico.

2. Processing



Raw natural gas contains water and various chemicals. Some of the gas also is mixed with oil. Processing plants, usually located near wells, separate the gas from the oil and water and remove other chemicals and impurities. Many of these raw natural gas by-products are used by industry.

3. Pipeline



Natural gas, now cleaned of impurities, is fed into a nationwide system of underground metal pipes. This pipeline network is over a million miles long and reaches into every region of the country. It is the most efficient fuel delivery system devised. Gas moves through the pipeline at about 15 miles an hour by a process called compression.

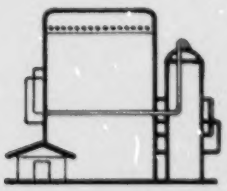
Major natural gas production areas.

To Do

The map shows major natural gas production areas and pipelines. Contact your local gas company to find out which pipeline (or pipelines) brings natural gas to your community. Draw a map of the route of that pipeline from your community back to the gas fields to find out where your community's natural gas comes from. Then add to the map the location of storage areas for your local gas company and where the pipeline comes into the local gas company system (this facility is called a city gate).

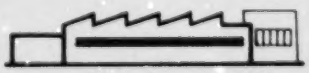
4. Storage

Because there is greater demand for natural gas during winter than during summer, gas is stored either as a liquid in specially designed tanks or as a gas in underground reservoirs during the summer. In winter, when demand increases, the gas is fed back into the pipeline system.



5. Utilities

The local natural gas distribution companies, called public utilities, buy natural gas from pipeline companies and deliver it to consumers. Before gas enters the local distribution system a chemical odorant (usually a rotten egg smell) is added to the gas as a safety precaution so that leaks can be detected and repaired.

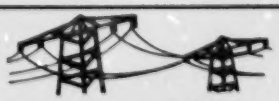


Industrial 40%

Industry and manufacturing are the greatest users of natural gas. Most of the products we use every day are either made from a process using natural gas heat, or are produced from the chemicals of raw natural gas.

Residential 29%

More than 55 million American homes use natural gas. Most of this gas is used for heating. The rest goes to hot water heating, cooking and clothes drying, in that order.



Electricity 19%

Electricity is a secondary form of energy that is generated from using a primary energy source, usually a fossil fuel or nuclear energy. Because natural gas is our cleanest fuel, it is valuable for generating electricity in high-pollution areas.

Commercial 12%

Stores and offices rely upon natural gas for heat and hot water. Restaurants rely upon natural gas as their favorite cooking fuel because it is clean and controllable.

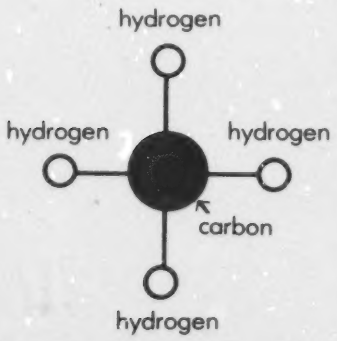
Foreword

Natural gas is almost entirely methane, a molecule of one carbon atom and four hydrogen atoms. The chemical formula for methane is CH_4. When methane burns, a process called combustion, energy is released. The methane molecule (CH_4) combines with two oxygen molecules ($2O_2$) to form two water molecules ($2H_2O$) and one molecule of carbon dioxide (CO_2), a harmless gas. Here's what happens:

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$$

In an ordinary chemical reaction such as this one, the atoms are neither created nor destroyed, but merely change places, from methane and oxygen to water and carbon dioxide. When they change places, energy is released.

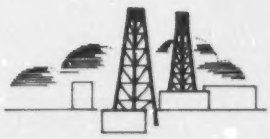
Methane Molecule

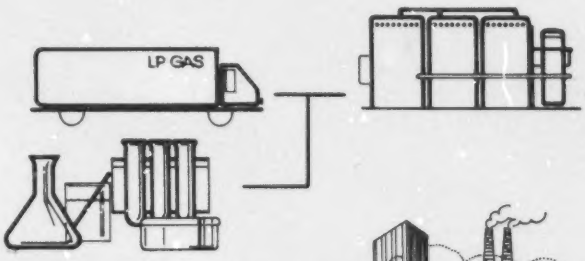


Most of the natural gas we produce goes to warming our homes, fueling our factories and cooking our food. But we also rely upon the components of natural gas to be the raw materials for a wide variety of products, from plastics and fertilizers to paints and fabrics. Consider the many things that come from a natural gas well:

Other Fuels

Natural gas is chiefly methane (CH_4), but raw natural gas also contains compounds with similar combinations of hydrogen and carbon. Ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) are fuels processed out of raw natural gas and used for special industrial fuel, LP-Gas (or bottled gas), and lighter fluid.



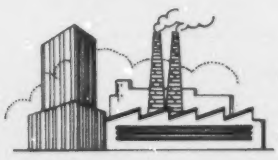


Chemicals

Raw natural gas also contains traces of liquid hydrocarbons, water, sulfur compounds and, often, oil. The water and oil are separated out of the gas, the liquid hydrocarbons are removed and used for making gasoline, and the sulfur that is processed out is an important chemical for scientific research and the pharmaceutical industry.

The following items are some of the many produced using natural gas heat:

aluminum
china
clothing
containers
copper
food
gasoline
glass
iron
motor oil
paper
steel



Industry and Manufacturing

The following items are produced by combining the chemicals of raw natural gas with other compounds:

adhesives
aerosol for spray cans
anti-freeze
camera film
carbonated beverages
cigarette filter tips
cleaning fluids and solvents
clothing dyes
clothing fiber
(Orlon, rayon, dacron and nylon)
detergents
explosives
fertilizers
fiberglass
gasoline anti-knock additives
hydraulic fluids
Lucite
oil-based paints
plastics
plastic tableware
Plexiglass
polyesters
printing ink dyes
printing paper coatings
PVC plastics
refrigerants
resins
rubbing alcohol
silicones
styrofoam
synthetic rubber
vinegar
water-based paints

Homes and Businesses

Natural gas provides energy for over 55 million American homes and office buildings, and it is the predominant energy source for restaurants. Most gas in homes is used for heating; most gas in restaurants is used for cooking. Because natural gas is our cleanest burning fuel, it remains in great demand.

Electricity

Electricity is a secondary source of energy. It is produced by consuming a primary energy source, usually coal, oil, natural gas or nuclear energy. About 12 percent of all the natural gas we produce goes to making electric power, and about 9 percent of our electric power comes from natural gas-fired generating stations.

To Do

Check with your local Chamber of Commerce to find out what products are manufactured in your community, and then check with those manufacturers to find out how natural gas is used, either to supply heat, or to be combined with other chemicals to make products, or both.

Compare the chemical composition of natural gas (methane) with the two other fossil fuels, coal and oil. Which fuel will produce the most pollutants when burned? Why? (Note: You may need to refer to the school library to find the chemical composition of oil and coal.)

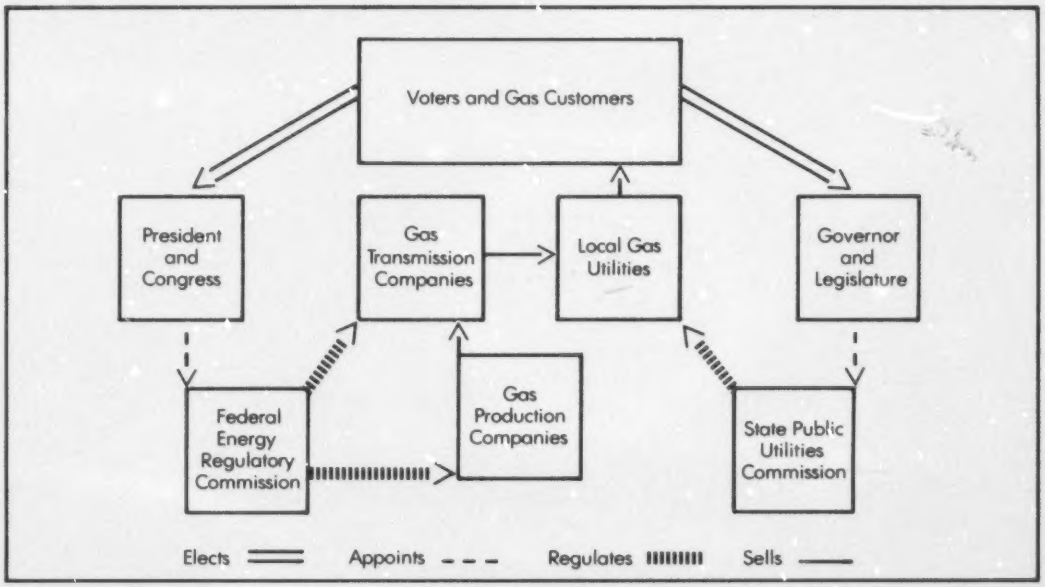
Foreword

Our society is based upon individuals working to make money to buy goods and services. Economics is the system by which we distribute what we need, such as food and clothing, and what we want, such as entertainment and education.

Most of these goods and services are provided through the private sector. That means that individuals invest money and work to produce goods and services that they sell for a profit. Necessities, such as food and clothing are, for the most part, provided in this manner. So, too, are non-necessity items, such as sports cars and video games. Large corporations, small shops and family farms are all part of the private sector.

The public sector–society acting through government–also produces goods and services. For example, the federal government has the exclusive right to provide our national defense, and state and local governments are the main providers of education and mass transit. But even when the public sector assumes the primary responsibility for providing certain goods and services, the private sector is often also involved. For example, state and local governments run public schools, but the private sector also operates schools.

This public-private cooperation is also evident in the system that provides all of our energy (except solar), including natural gas. In the natural gas industry, the private sector (individual companies working for a profit) finds and drills for natural gas. These are called production companies. Other private companies, called transmission companies, own and operate the natural gas pipelines that transport the natural gas from wells to cities. Transmission companies operate for a profit and these profits are returned to those who have invested their money in the companies, or the profits are put back into the business to produce and deliver more natural gas. In this way, the continued availability of natural gas is ensured.



Because this continued supply of natural gas is so important to our nation's economy–natural gas is our largest domestically produced energy source–the public sector, acting through the federal government, regulates the gas production and transmission industry.

The Federal Energy Regulatory Commission (FERC) is appointed by the President, with the consent of Congress, to oversee the operations of production and transmission companies. Acting under a variety of Federal laws, the FERC establishes the maximum allowable price that producers can charge for the gas they sell to interstate pipeline transmission companies. It also sets the price the transmission companies can charge the local gas companies for natural gas.

Most local gas companies are private corporations that operate for a profit. Others are owned directly by the local government. Private local gas companies (called investor-owned utilities because they are owned by individual stockholders) have a charter from state and local governments to provide exclusively natural gas service in a certain area. As a result, local gas companies do not compete with each other as do, for example, grocery stores. Many stockholders of local gas companies are employees of the companies themselves and often residents of the area it serves.

While a charter gives a gas company the exclusive right to provide service in an area, it also requires that the gas be sold to customers at the most reasonable price possible. To ensure this, state and local governments regulate the local utilities.

The regulation of local gas companies is usually done through a state public utility commission (your state may have a different name for this body: if you're in a city, the city council may perform this function). The public utility commission is usually appointed by the governor with the consent of the state legislature. In some states, public utility commissioners are elected directly by voters.

Regardless of how this body is chosen, its job is to set the rates customers pay for natural gas service, and to ensure that the local gas company is able to continue to serve the community. The rate customers pay is comprised of the cost of the natural gas, the operating cost of the delivery system, and a reasonable profit for the stockholders of the company.

This system of public utility regulation means that while the private sector provides natural gas, the public sector oversees the system and establishes the rates being charged consumers.

To Do

Every state and city has a slightly different system for regulating local natural gas companies. The diagram shows a typical arrangement. Find out who regulates the gas company that serves your community and draw your own diagram. Remember to include what your state calls its public utility commission and how this body is selected.

Foreword

The natural gas industry is one of the nation's largest. Gas companies are located in every state, in cities large and small, in rural areas, in remote wilderness. As a result, the industry offers a wide variety of employment opportunities.

Gas companies recruit college graduates for scientific, technical and management positions. They also seek out and train employees with high school and vocational school education for construction, operation and maintenance positions. There is also a need for qualified administrative support, especially employees who are good with people and managing office work.

Your first step is to determine what you might like to do (look at your hobbies, skills and interests), find out what kind of jobs will allow you to do that, and then decide what training or education you'll need to qualify for those jobs. Following are some jobs available in the gas industry. The list is divided into those that require college and those that don't, and it includes a few duties of each position and the types of skills those who are successful in the job usually have.

College

Engineer: Chemical, civil, electrical, mechanical and general engineers are in demand. Engineers plan and oversee the installation, operation and maintenance of equipment and plants and develop solutions to technical and scientific problems. People who are good at analyzing technical data, and who do well in science and mathematics make the best engineers.

Geologist: The scientists who study the physical properties of rocks are the first to be involved in the search for natural gas. They evaluate the gas-bearing potential of rock formations and recommend where to drill. Curiosity and an ability to analyze scientific data are important. So, too, is a solid background in physical science and mathematics.

Administrator: Managing large gas companies requires college training in the areas of finance, accounting, personnel and data management, among others. An ability to communicate, to supervise others and to organize time and projects is essential.

Marketing: Gas companies need qualified professionals who can sell products and services, and who can plan marketing, advertising and public relations activities. An interest in working with people and a background in sales and personnel management are essential. People who are outgoing and can communicate well make the best marketing executives.

High School and Vocational School

Computer Operations: The gas industry was one of the first to use computers, and qualified programmers, operators and repairpersons are needed. People who can analyze problems and are comfortable working with machines do best working with computers.

Technician: Operating the complex equipment used to produce, transmit and deliver natural gas requires skilled technicians. Most of the training comes on the job, but good technicians need to be able to understand how machines work and have to be good with their hands. They also have to be able to plan their work and to assume responsibility.

Consumer Service Representative: Because the gas company serves the public, it employs many people whose job it is to respond to customer inquiries, complaints and service requests. An ability to get along well with people, to solve problems, and to speak and write clearly are essential. People who enjoy retail sales work enjoy this position.

Office Worker: Gas companies require clerical and administrative support–clerks, typists, accounting assistants, secretaries and administrative assistants. Strong typing skills, knowledge of business practices, good communications skills and an ability to organize time and work are essential. Recently, companies are looking for employees trained in word processing.

GAS COMPANY JOB APPLICATION

– PLEASE PRINT –

POSITION REQUESTED:_____ DATE:_____

NAME:_____
LAST FIRST MIDDLE

ADDRESS:_____
NO. STREET CITY STATE ZIP

HOME PHONE: ( )– SOCIAL SECURITY NO:_____

DATE OF BIRTH:_____ CITIZENSHIP:_____

SPECIAL SKILLS:_____

SCHOOL ACTIVITIES:_____

HOBBIES/COMMUNITY ACTIVITIES:_____

PRESENT/LAST EMPLOYER:_____

ADDRESS:_____

FIRM'S BUSINESS:_____ STARTING TITLE/PAY:_____

DATES WORKED: FROM_____ TO_____

CURRENT OR FINAL TITLE/PAY:_____

MAJOR DUTIES:_____

SUPERVISOR:_____ PHONE:_____

REASON FOR LEAVING:_____

SCHOOL	CITY/STATE	FROM	TO	GRADUATED	COURSES

TYPING SPEED:_____ SHORTHAND SPEED:_____ LANGUAGES:_____

OFFICE OR SHOP EQUIPMENT OPERATED:_____

SIGNED:_____

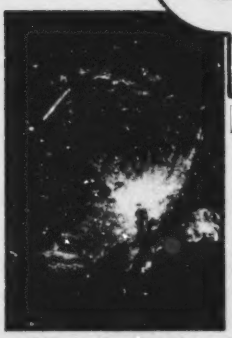
Applications and Interviews

Regardless of what job you seek, you'll probably need to fill out a job application and have an interview. Application forms tell the company something about you. This form is a sample of one you might encounter. On a separate sheet of paper, supply the information requested, just as if you were applying for a job. Neatness is particularly important in filling out a job application.

NATURAL GAS ENERGY BOOKLET

NATURAL GAS ENERGY

CH_4



A BACKGROUND

This is the story of natural gas, what it is, where it comes from and how we use it. It is also a story of energy, and how the decisions we make today affect our future.

To understand those decisions, our need for and use of energy, and the role of natural gas, consider the nature of our physical universe.

The prevailing scientific theory is that the universe, everything that exists — energy and matter — all began about 20 billion years ago with a cataclysmic explosion called the Big Bang. While we do not know why the Big Bang occurred, we are learning many things about the universe. For example, we know that it is almost inconceivably large. Among the most distant objects from us are mysterious radiation sources called quasars — they're about 10 billion light-years away. A light-year is the distance light, the fastest thing we know, travels in a year, about 6 trillion miles.

We also know that in all the universe, there exists only matter and energy.

Matter is composed of atoms, it takes up space and it can be perceived by our senses. Matter exists in one of three states — solid, liquid or gas. We know that it can change from one state to another under certain conditions, such as when water (a liquid) freezes into ice (a solid) or it boils into steam (a gas). We also have observed that when matter changes form, energy is exchanged.

What, then, is energy? It is not composed of atoms and it takes up no space. Energy is the capacity to do work, to exert a force on matter, to make things happen.

There are many different kinds of energy — for example, heat, light, chemical, nuclear, magnetic, motion, gravitational — but it's all energy, it's all a force being exerted on matter.

Energy cannot be created or destroyed. However, it can change from one form to another. An example is when the chemical energy of gasoline is changed into heat energy in a car's engine, and then into the energy of motion in the car's movement.

When energy seems to be created or to disappear, it is merely changing from one form to another. In fact, most of the time we use energy, we change it from one form to another form that is more convenient for the work we want to do. Usually, machines are used to make this conversion. For example, a light bulb converts electrical energy into light energy.

The sun is the basic source of most of our energy. It directly provides heat and light; and it indirectly is responsible for the energy stored in coal, oil and natural gas; for the energy stored in plants and animals; and, for the energy potential of wind and water.

Nuclear energy is the other basic source of energy. It comes from the splitting or fusing of certain atoms, usually in a controlled reaction.

In a nuclear reaction, as in the sun, matter is changed into energy.

Fuel is matter that can be converted conveniently, usually by burning, to release energy. Fuels provide much of the energy in our society. The most widely used are the fossil fuels — coal, oil and natural gas. They are called fossil fuels because they come from the ground. The word "fossil" comes from the Latin word meaning "to dig." Coal, oil and natural gas also are called hydrocarbons because they are composed mainly of hydrogen and carbon atoms.

Coal, the most abundant fossil fuel, is almost entirely carbon, with only a small amount of hydrogen. Oil, the most used fossil fuel, is a mixture of many different types of hydrogen and carbon molecules. Natural gas, the cleanest fossil fuel, is composed almost entirely of methane, a molecule of one carbon atom and four hydrogen atoms.

Because of this chemical composition, the scientific symbol for methane is CH_4.

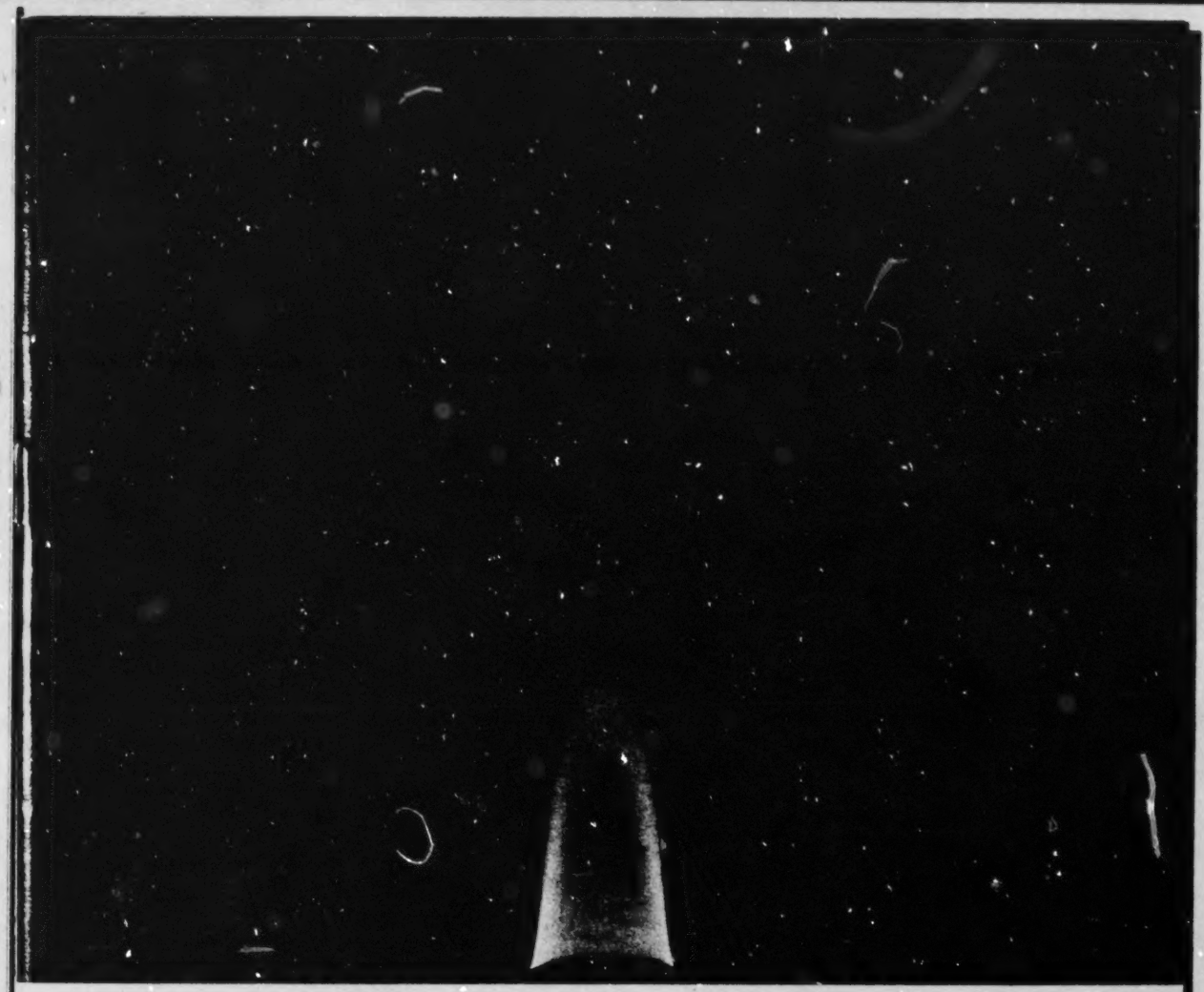
COMBUSTION

Methane can burn and release energy. This process is called combustion.

When it burns, each of its molecules joins with two oxygen molecules to make water and carbon dioxide. Using chemical shorthand to express this:

CH_4 (one methane molecule) + $2O_2$ (two oxygen molecules) becomes $2H_2O$ (two water molecules) + CO_2 (one carbon dioxide molecule).

The atoms, have just changed places, none is lost or gained. Matter has changed form, from methane and oxygen to water and carbon dioxide. What is released is energy.



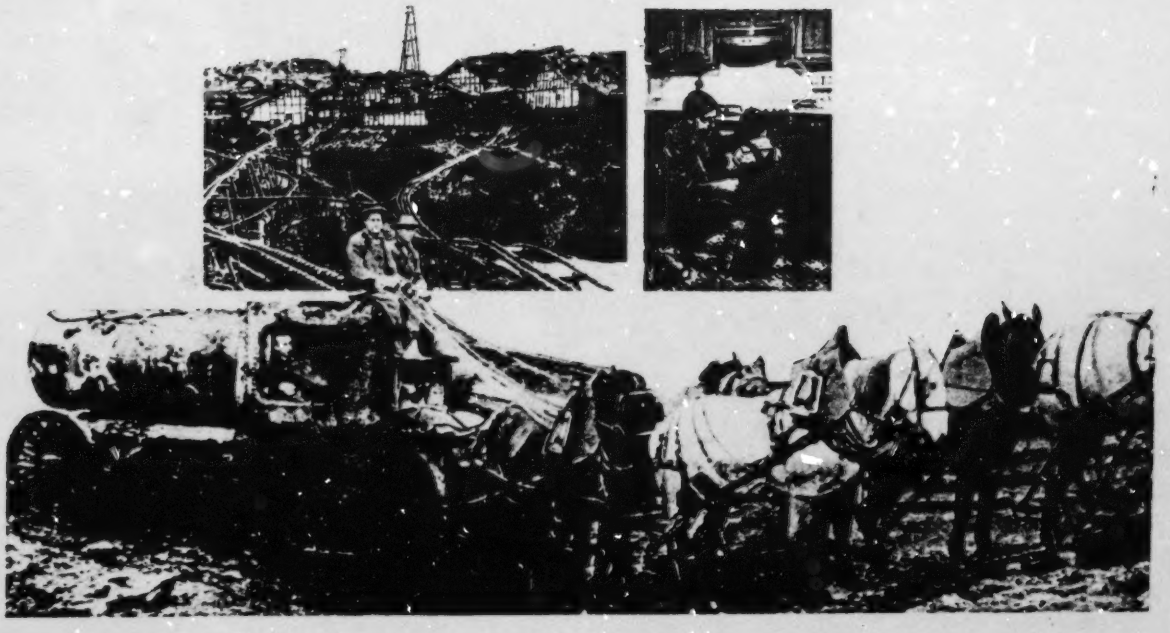
The Story of Natural Gas Energy

Many legends surround the early discovery and use of natural gas. Centuries ago man noticed natural gas that seeped from the ground and was ignited by lightning, creating "burning springs."

The most famous ancient legend about natural gas started on Mount Parnassus in Greece about 3,000 years ago. About that time a goat herdsman discovered a burning spring on the mountain. Eventually, a temple was built on the spot and a priestess was chosen to speak the prophecies inspired by the burning spring. That priestess was the famous Oracle of Delphi.

Burning springs of natural gas also appeared to be prominent in the religious practices of ancient Persia and India where temples were built to surround these "eternal flames." Neither the Greeks, the Persians nor the Indians, however, recognized the energy value of natural gas. The ancient Chinese first realized that this burning gas could be put to work. About 2,500 years ago, the Chinese piped natural gas from shallow wells through bamboo poles. The gas was burned under large pans to evaporate sea water from salt.

The gas industry began in Britain about 1785. A Scotsman named William Murdock improved on a method of manufacturing gas from coal. He used this manufactured gas to illuminate his home. A few years later, the first gas company



was formed and the streets of London were illuminated with gaslight.

Manufactured gas first came to America in 1816 when gaslights were installed along the streets of Baltimore. Like the gas that illuminated London, this gas was manufactured from coal. This manufactured gas had a much lower energy content than the natural gas we use today.

Natural gas seeping from the ground had been noticed throughout eastern America and along the California coast by explorers. In 1626, French missionaries recorded that Indians in what is now New York state ignited gases in the shallows of Lake Erie and in the streams flowing into the lake. It was in this same area that the natural gas industry in America began. Its birthplace was Fredonia, New York, a small village on the Canadaway Creek near Lake Erie.

The Fredonia story starts in 1821. Residents of the town noticed bubbles of gas in the creek. This news attracted the attention of a gunsmith named William Hart. He was the first to put natural gas to work in America, and is considered to be the "father of natural gas" in this country.

Hart dug the first natural gas well in America along the creek outside Fredonia. His equipment was a crude spring pole arrangement with a sharp chisel. It was powered by two men kicking the chisel into the shale rock. That first well was about 27 feet deep. By contrast, today there are natural gas wells that are drilled over 30,000 feet deep.

Others expanded on Hart's work and by 1858 a group had formed The Fredonia Gas Light Company, the nation's first natural gas company. In the 40 years that followed, natural gas well drilling continued throughout western New York and Pennsylvania, and in northern Ohio and Indiana. By 1900, natural gas had been discovered in 17 states.

Throughout this period, and well into the 1920s, natural gas continued to compete with gas manufactured from coal. The facilities used to manufacture this gas from coal usually were located in cities. By contrast, an efficient pipeline system to transport natural gas from wells to cities had not yet been developed.

The need for energy continued to grow as our population grew. During the past 130 years, the population of the United States has increased from about 23 million to over 221 million. This increase, accompanied by a growth in American industry, has resulted in the use of 33 times more energy than was used 130 years ago. On the average, each of us is using four times more energy than our great-grandparents used. This growing per-capita energy use has been a contributing factor to our achieving a standard of living unequalled in history.

Throughout our history we have looked to different energy sources to meet our needs. During the Colonial period, human and animal muscle, and wood provided most of the energy. Just after the Revolutionary War, with about 4 million people in the country, wood continued to be the major fuel. By 1850, America was starting to

Today, natural gas is delivered to over 55 million American homes through a million-mile network of underground metal pipe. About 2,500 years ago, the Chinese piped gas through hollow bamboo poles. In some areas of China, bamboo gas pipes still exist. In America, the first pipelines were made from hollowed-out logs. Later, iron and steel were used. It was not until the 1920s that advances in making steel allowed the building of a nationwide pipeline system.

change from an agricultural to an industrial nation, but even then wood continued to provide 90 percent of our energy, with coal and water power supplying most of the balance.

By 1890, coal had become the nation's major energy source. It accounted for nearly 60 percent of our usage, while wood provided 35 percent and oil and natural gas together accounted for only 5 percent. By 1910, wood had almost completely disappeared as an energy source, and coal continued to dominate usage after World War II. It was not until 1950 that oil became our leading energy source.

Oil is still our major source of energy. It provides about 45 percent of our energy. Natural gas provides 27 percent, coal 20 percent, hydropower 4 percent and nuclear energy 4 percent.

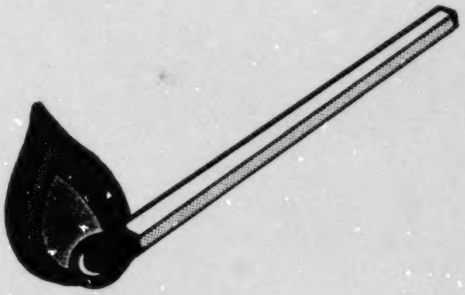
Today, our nation's biggest energy problem is that nearly half the oil we use is imported. Each year we pay other nations about $80 billion for oil — that's more money than the net worth of the nation's three largest corporations, combined. This massive dollar outflow has weakened our economy by increasing energy costs, inflation and unemployment.

By contrast, over 95 percent of our natural gas energy is produced within the United States. Almost all of the remaining 5 percent is imported from Canada and Mexico. As our nation's need for energy continues to grow, so too should the demand for more domestically produced energy sources, such as natural gas.

THE NATURAL GAS SYSTEM

Finding natural gas, drawing it from the ground, cleaning it of its chemical impurities, storing it until needed, and then piping it to consumers is a complicated task. To accomplish this work, the natural gas industry is divided into three distinct segments, each with specific responsibilities:

- *Production companies* explore for, drill and extract natural gas from the ground.
- *Transmission companies* operate the pipelines that link the gas fields to major cities.
- *Distribution companies* are the local utilities that purchase the natural gas from the transmission companies and deliver it to consumers.



COUNTING ENERGY

We buy gasoline in gallons, coal in pounds, natural gas in cubic feet and wood in cords. Each of these resources has a measurable amount of heat energy stored in it. To add up the energy potential of these different resources, we convert each to a common measure.

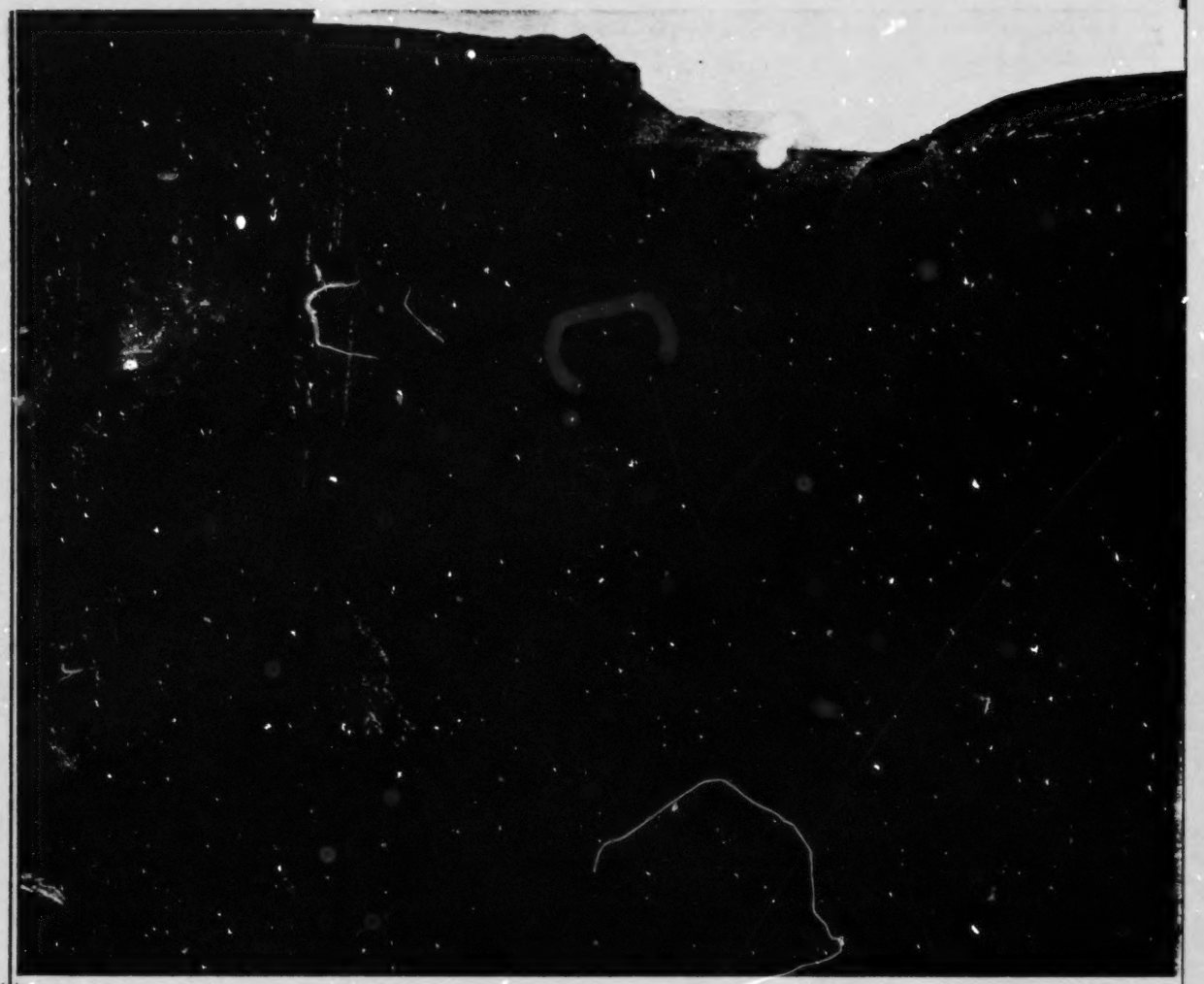
A common measure of heat energy is the British thermal unit (Btu). Each Btu is the heat needed to raise the temperature of one pound of water one degree Fahrenheit.

A gallon of gasoline has about 125,000 Btu, a pound of coal about 11,125 Btu, a cubic foot of natural gas about 1,021 Btu and a cord of wood about 28 million Btu. Numbers of that size are difficult to understand, especially since we don't think of water by the pound. An easier way to understand the energy value of a Btu is to remember that burning a kitchen match releases about 1 Btu. It takes about 60 Btu to heat the water for a cup of coffee.

With that in mind, consider how much energy America used in 1980:

75,913,000,000,000,000 Btu.

That's 75.9 quadrillion Btu. A quadrillion Btu are called a quad. A quad is the amount of heat energy used in a metropolitan area such as San Francisco or Boston in a year. By the year 2000, experts estimate that the United States could need up to 100 quads of energy each year.



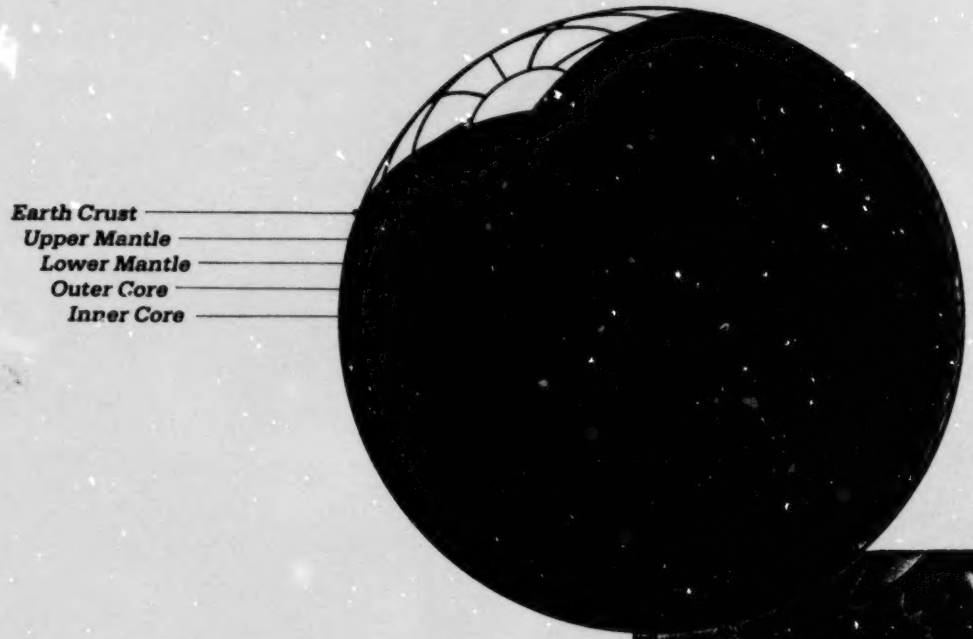
Formation

One theory of Earth's origin is that the planet was formed out of a condensing cloud of cosmic dust that swirled around the sun some 5 billion years ago. The sun itself may have been formed from the center part of this cloud, and the other planets evolved from this cloud at about the same time as Earth.

The particles from this dust cloud began to condense and were drawn together by gravity. As Earth grew in size, the temperature of its interior increased as a result of compression and radioactive decay. This intense heat melted much of the inner portion. During this molten stage, the components of the planet separated to produce a heavy central core about 4,500 miles in diameter, a mantle of lighter rock some 1,800 miles thick, and a crust of the lightest rock some 5 to 20 miles thick.

It was during this molten stage that large quantities of water vapor and various gases escaped from the core and erupted through the crust to combine with other gases and form the planet's atmosphere. This early atmosphere may well have been mostly ammonia and methane gases, similar to the atmosphere now surrounding Jupiter, or it may have contained large amounts of carbon dioxide, such as the atmosphere of Venus.

Slowly, Earth cooled, and as it cooled it shrank. Some of the water vapor that escaped



A geologist studies rock outcroppings.

from the crust cooled into liquid and settled in surface depressions to form early oceans.

As the atmosphere evolved and the planet's surface cooled, rain began to fall, forming rivers and enlarging oceans. The running rainwater and rivers, as well as wind, moving ice and waves, carried with them particles of rock from higher to lower places.

This process is called erosion. The settling of these rock particles is called sedimentation. Together, erosion and sedimentation gradually change the face of the planet.

Other forces produce changes in the planet's surface. Temperature changes, water and wind break down rocks to help form sand and soil. Wind and water wear away rock to form canyons, and glaciers can reshape mountains and move soil thousands of miles.

Changes also can be caused by shifts in Earth's crust. For example, the Rocky Mountains were formed when the crust broke into great blocks that were then slowly tilted or lifted up. By contrast, the Appalachian Mountains were formed when layers of the crust wrinkled into wavelike folds.

Slow movement of the crust may also explain the shape and location of the continents. A theory called plate tectonics holds that the crust is made up of two layers, one resting on top of the other. The top layer, on which the continents sit, can move very slowly along the bottom layer. There is evidence to suggest that at one time there was only one large land mass. About 200 million years ago, this land mass

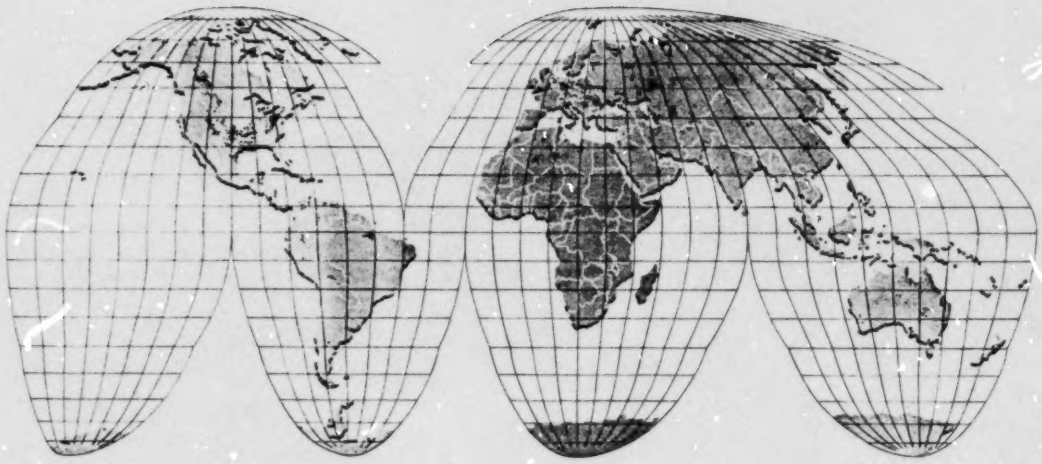
ANOTHER ORIGIN OF METHANE

Most geologists believe that methane, the chief component of natural gas, was formed from decomposing organic material. As a result, most natural gas drilling is in areas of sedimentary rock where methane may be trapped.

Another theory, the abiogenic theory, holds that most methane was formed 5 billion years ago when Earth was formed. This methane was trapped beneath Earth's crust and is now seeping out slowly.

As part of the evidence supporting this theory, earthquakes and volcanoes often are accompanied by discharges of methane. In addition, if methane was formed only from decayed organic matter, as is oil, then it should be found near oil. A large amount of methane is found in areas away from oil deposits, suggesting that the origins of methane and oil may be different.

If the abiogenic theory of methane origination is proven, it could change significantly where we would expect to find natural gas. Today, most of our drilling is in relatively shallow sedimentary rock areas. If there are large quantities of abiogenic methane, they could be tapped by drilling deeper and in areas previously ignored.



Known natural gas deposit areas.

separated and started to drift apart, forming the continents and the oceans between them.

For the first 1.5 billion years or so of its existence, Earth was lifeless. Then life began to form in the ocean. Algae and bacteria were probably the first living things. Plants appeared on land about 400 million years ago, dinosaurs and mammals about 225 million years ago, and man about 4 million years ago.

The development of life on the planet is important to the formation of fossil fuels—coal, oil and natural gas. The most commonly accepted theory about the origin of these fuels is the organic theory. It holds that over millions of years, billions of plants and animals lived and died. The remains of this organic matter are deposited along with the rock particles that form sedimentary rock. In time, additional layers of sediment, some combined with organic matter, are deposited. Eventually, the mud and sand become sedimentary rock, trapping the organic matter. This organic matter decays through the action of heat and pressure, and from the effects of bacteria and radioactivity.

Organic decay releases carbon and hydrogen, which combine to form hydrocarbons — coal, oil and natural gas. The simplest combination of carbon and hydrogen is methane, CH_4. Natural gas is almost entirely methane.

This methane gas is contained within the voids of porous sedimentary rock. Often it escapes into the atmosphere. However, if the porous sedimentary rock is contained by impermeable rock, then the gas is trapped in the pores or fractures in the rock. A path can be made for the gas to get to the surface by drilling a hole through the impermeable rock into the sedimentary rock holding the gas. In the simplest terms, this is how we get natural gas from the ground.

Aerial surveys and geological maps help geologists locate potential gas-bearing rock formations.

ROCKS

There are three types of rocks, and each is important to our understanding of fossil fuels.

Rock formed from within Earth's crust is called igneous. It starts as molten material and cools and solidifies into rock. Granite is an igneous rock.

Erosion and sedimentation are the processes through which sedimentary rock is formed. Layer upon layer of rock material, worn away by erosion, settles into lower places. Each layer is compacted by the weight of overlaying layers. Over millions of years, these sedimentary layers are compressed into rock and become located at or near the surface. Sedimentary rock is important to our understanding of energy because it is in these rocks that most of our oil and natural gas resources accumulate. Sandstone, limestone and shale are sedimentary rocks.

The third type of rock is called metamorphic. It is the result of extreme heat and pressure on either igneous or sedimentary rock that changes the texture or structure of those rocks to form a new rock. Quartzite is a metamorphic rock.

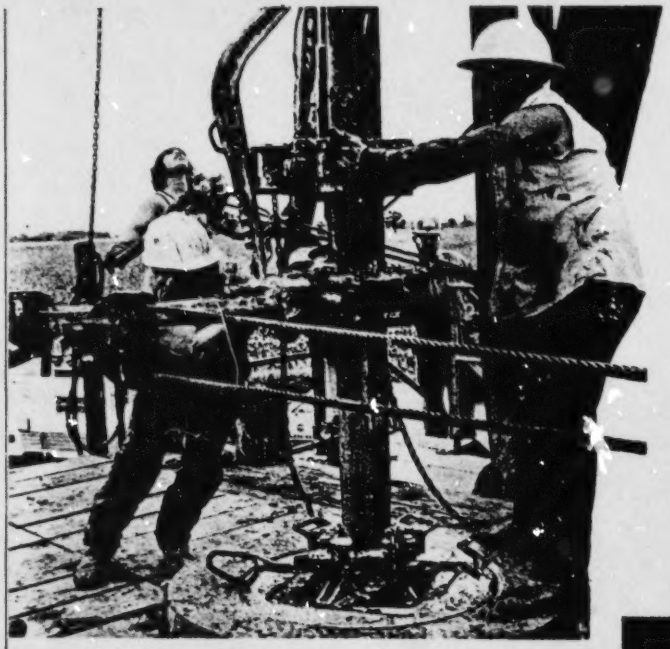
Exploration & Production

The United States produces more natural gas than any other nation. With only about 10 percent of the world's known gas, the U.S. produces about 40 percent of the world's gas each year. Almost all of this gas comes from wells drilled in the lower 48 states, or along the shoreline. In recent years, more than 15,000 natural gas wells were drilled in this country annually.

Determining where to drill depends upon understanding the origin of natural gas, and then upon gathering and interpreting data on underground geological formations. Geologists specialize in the study of Earth's structures and are the first involved in exploring for gas.

The basis for their search is the knowledge that natural gas generally is found in sedimentary rock. The search begins with a review of geological maps of likely areas for exploration. These maps accumulated by geologists and prospectors over the years, are supplemented by aerial photographs and, in recent years, by infrared photographs taken from satellites. Different types of rocks show up at different intensities in these satellite photographs, allowing a skilled interpreter to determine geological formations in a particular region.

If the preliminary indications are good, further data gathering is done after the exploration company secures a lease for the land. A gravimeter measures variations in the gravitational



Roughnecks work on a rotary rig.

ESTIMATING CONVENTIONAL GAS SUPPLIES

Conventional gas is natural gas extracted from the ground by conventional methods. Most of the natural gas we use is conventional gas.

Short of extracting this gas from the ground, we can only estimate how large a supply of gas we have.

The estimates we are most certain about are called proved reserves. We know where this gas is; we have the technology to extract it; and, current economic conditions seem to justify its development.

In addition, we have a supply of natural gas in potential resources. This is gas that experts are reasonably certain exists and can be extracted given expected advances in technology and economic conditions.

Christmas tree.

pull of the earth. Different types of underground formations exert different gravitational forces. For example, porous sedimentary rock tends to have a lower gravitational pull than igneous rock. With this data, a gravity map can be drawn, suggesting the location of possible gas deposit areas.

A magnetometer towed behind an airplane can detect differences in the magnetic field of a region. Sedimentary rock is usually nonmagnetic, and igneous and metamporphic rock is usually highly magnetized. Since gas is most often found in sedimentary rock, a map of the magnetic field of a region can indicate the location of potential gas-bearing rock.

A seismograph measures the variations in seismic waves caused by the rock formations through which they pass. Seismic waves are vibrations similar to sound waves. Seismographic testing is a precise and commonly used exploratory method that operates on the principle that different densities of rock reflect seismic waves in different ways.

To create a seismic record of the underground structure, a series of seismic detectors is set up on the surface. An explosive charge is then set off, or the ground is struck by hydraulic vibrators. The detectors record and measure the resulting seismic waves that bounce back from the rock below the surface. By repeating the test at carefully spaced locations and measuring the time it takes for the waves to reach the detectors, a very accurate map of the underground rock formations can be drawn.

Despite all of these tests, the only way to be certain that natural gas is in a particular area is to drill a hole in the ground. Simply put, a gas well is a hole that serves as a channel from the underground gas source to the surface. The same principles apply whether the well is drilled on land or off the shore, although with offshore drilling there is the added problem and expense of working in deep water.

Since the days of William Hart, the methods of drilling have changed dramatically. In 1821, Hart's drilling equipment was a foot-powered chisel apparatus that dug a 27-foot deep hole into soft shale. Later, mechanized rigs pounded pipe into the ground to make the wellhole. Today, most gas drilling is done with rotary rigs that turn rapidly as they bore through the rock.

A rotary rig is a factory designed to produce one thing—a hole. Unlike other factories, this one is portable, since it must be moved from site to site. The average rotary rig costs more than $500,000; those designed to drill to great depths can cost more than $2 million.

In a rotary rig, an engine turns a round flat table that surrounds and is connected to lengths of metal pipe. At the end of the pipe is a drill bit that bores through the rock. As the drill bit cuts through the rock, the pipe is lowered and another section of pipe is connected. Once several lengths have been added, the assembly is

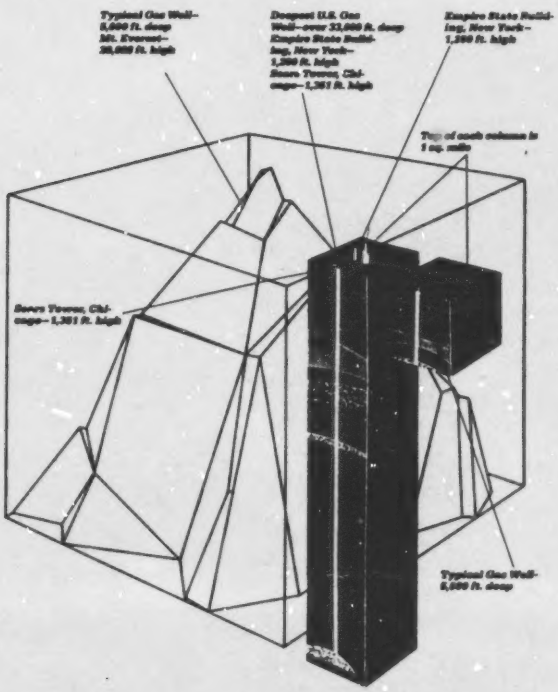
called a drill string. The method is similar to boring a hole through wood with a carpenter's drill.

A typical gas wellhole is about 6 inches wide. As the drill bit grinds through the rock, it leaves behind rock shavings. To clean these shavings from the wellhole, and to cool down the drill bit, a special chemical solution called drilling mud is pumped through the center of the drilling pipe into the wellhole and then out around the pipe, bringing with it the shavings.

The drill string of pipe must be extended whenever the bit has dug down to the deepest point possible with the length of pipe in place. The derrick that rises 100 to 200 feet above the ground is used to hoist these 30-foot lengths of pipe so that they can be joined together and allow the drilling bit to go deeper.

Drill bits rotate at a speed of up to 3,000 revolutions per minute. The total weight of the drill string can be more than 100 tons.

When the drill bit penetrates the rock formation containing natural gas, the drill string is disassembled and removed from the wellhole, and the difficult process of completing the well in preparation for gas production begins. The well is enclosed in casing, a high-strength metal pipe that is welded together and cemented into place. The casing is often put in place during the drilling operation to prevent the walls of the well from caving in. At the top of the well, the drill crew installs a complicated assembly of pipes and valves called a Christmas tree because of its appearance. The Christmas tree regulates the flow of the gas from the well.



The drilling of a gas well may take anywhere from a few weeks to several months, depending upon depth and the difficulty of drilling conditions. The whole process, from the investigation of the site to the capping of the well with a Christmas tree, can cost as much as $10 million.

Even with such high costs, the success of a well is not certain. For example, the deepest well drilled in this country was over 5 miles deep; it was finally abandoned when no gas was found. On the average, one out of every three wells drilled in known gas deposit areas produces gas. The success rate is much lower in areas that are not yet proved to have gas deposits. In these areas only one in seven results in a producing well.

The gas that comes out of the well usually is not ready to go into the pipeline directly. About a third of all the gas discovered is found in combination with oil. In these cases, the oil and gas are separated at processing stations near the well site.

Natural gas in the ground is mainly methane (CH_4), but the raw natural gas that comes from the well also contains small amounts of many other hydrocarbons, such as propane and butane. These hydrocarbon gases are processed out of the raw natural gas and used for specialized fuel purposes.

Raw natural gas usually contains water vapor, which is removed, as are other elements. The most important of these is sulphur. Raw natural gas with a high sulphur content is said to be "sour." Sulphur can be a dangerous substance, especially when it combines with hydrogen to form poisonous hydrogen sulfide gas. However, sulphur separated from raw natural gas is a valuable chemical for industry.

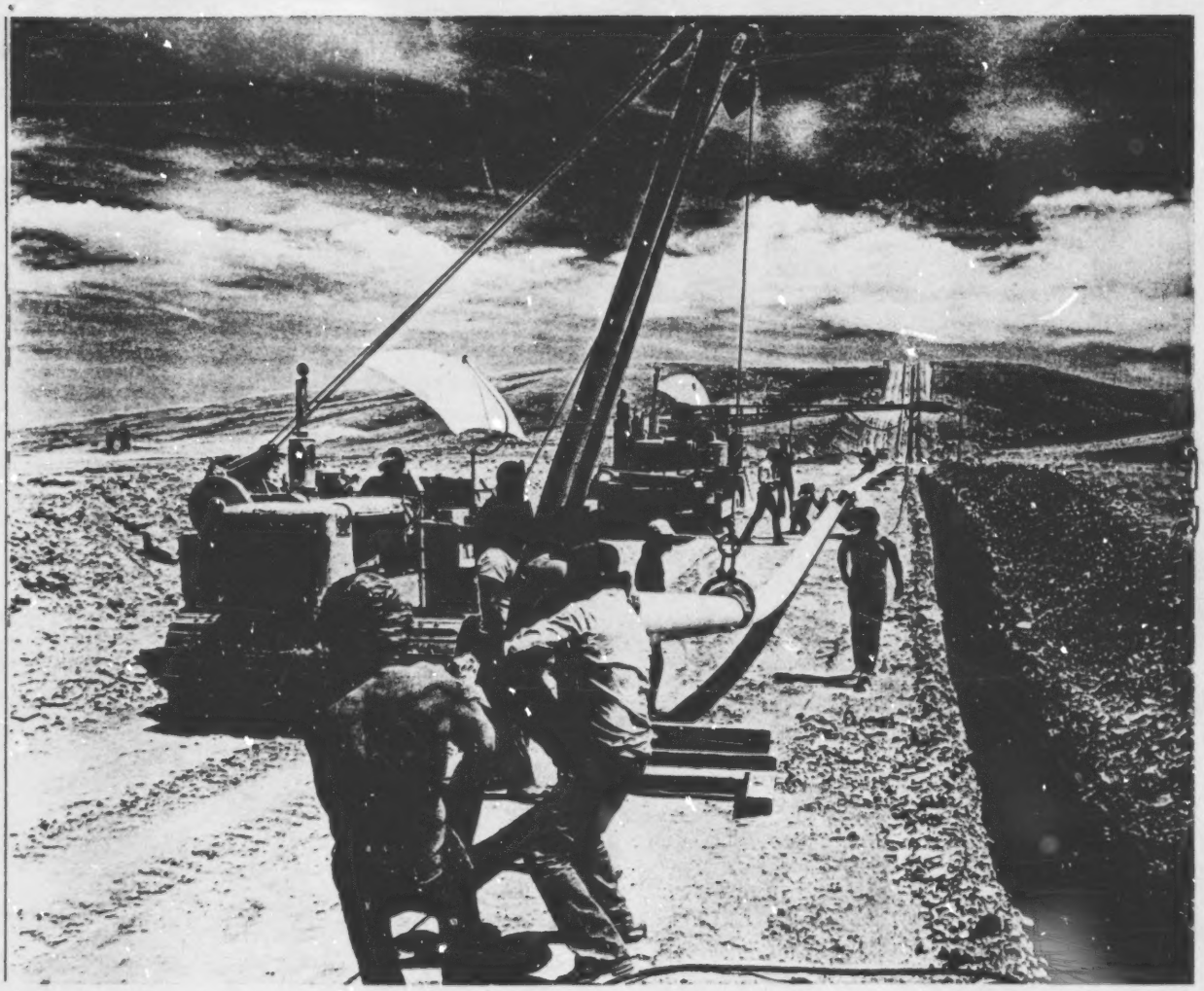
From the processing station, the natural gas is now ready to enter the nation's most efficient fuel delivery system.

GAS FROM OFFSHORE WELLS

Wells drilled off our shores account for about 27 percent of our current natural gas production. Most of these wells are located in the Gulf of Mexico off the Texas and Louisiana shorelines. Others exist off the Atlantic, Pacific and Alaskan coasts.

The procedures and equipment used in drilling for gas under water are very similar to those used in land drilling. Offshore drilling rigs rest on constructed platforms that are either secured to the seabed or float on the water. These drilling platforms generally have fully equipped living quarters for the crews.

The cost for an offshore well can be as much as five times the cost of a comparable land well.



Transmission & Distribution

Natural gas moves through underground pipes. A million-mile network of these pipes stretches throughout the nation, linking gas wells to consumers, and linking America to the gas fields of Canada and Mexico.

This underground network is the most efficient fuel delivery system in the world. It cost over $65 billion to build.

The first natural gas transmission lines were hollow logs. Later, lines were made of lead or iron pipes. These pipelines met the need for a while, particularly over short distances.

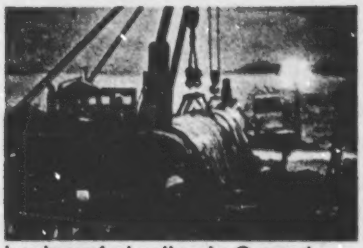
By the late 1920s advances in steel-making made possible the high pressure, long distance pipelines that serve the nation today. Between 1930 and 1960, natural gas pipelines were extended into nearly every populated region. During that period the demand for natural gas increased five times.

Today, gas transmission lines are in every state, including Hawaii where the pipelines carry a methane gas made from oil byproducts since there is no natural gas production in that state. If all the transmission pipes in America were laid end to end, they could reach beyond the moon, some 239,000 miles away.

Most of the pipelines carrying natural gas across the country are 14 to 30 inches in diameter, but some are as large as 42 inches across.

Building a natural gas pipeline is an extensive

Major natural gas transmission pipelines in the United States.



Laying of pipeline in Canada. Eventually this Canadian section will be linked to U.S. sections to form a route from Alaska to the lower 48 states.

and costly project. The first step is to obtain permission from the federal government to build the line. A company must prove that there is a need for the gas that will be transported through the line, and that there is a long-term gas supply to meet that need. Next, the best route must be determined. The goal is to prevent environmental concern and to avoid physical features such as lakes where pipelaying would be particularly expensive. Federal, state and local safety and environmental standards must be met throughout the project.

Once the best route is determined, rights-of-way are purchased. This does not mean that the pipeline company purchases the land on which the pipe will be laid. Right-of-way agreements provide for rental payments for the use of a corridor of land, usually about 100 feet wide, along the entire route of the pipeline. This width is required to accommodate the machinery that will be used to lay the pipe in the ground.

Now construction begins. A trench, approximately three feet deep and four feet wide is dug, and the sections of steel pipe are lined up next to the trench. Then welders join the pipe sections together and machine wrap the pipe with a tar-like material to prevent rusting after the pipe has been laid into the ground. Sideboom tractors then lift the continuous tube and lower it into the trench, covering the pipe with dirt as they move along. Crews come along after the pipe is underground to restore the right-of-way to its original condition.

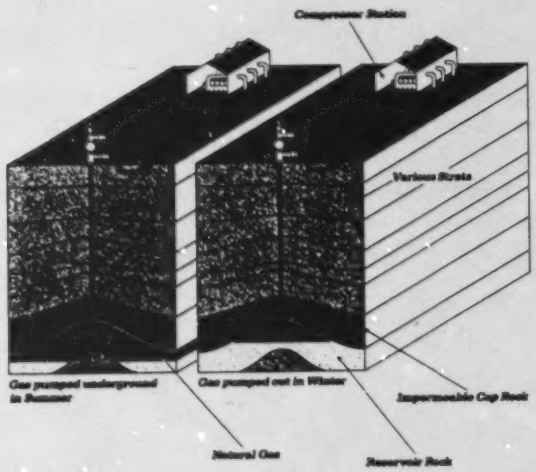
ALASKAN NATURAL GAS PIPELINE PROJECT

Commercial concentrations of natural gas were first discovered in Alaska in 1945. Most of Alaska's gas is found on the Northern Slope, above the Arctic Circle, and off that state's southern and western coasts.

One of the biggest problems in recovering this gas is that there is no way to transport it conveniently to cities in the lower 48 states. To solve this problem, some gas companies are now planning the construction of a 4,800-mile natural gas pipeline that would run from Prudhoe Bay in Alaska, through western Canada, to connect to existing pipeline systems in the Midwest and the West.

When completed, the Alaskan natural gas pipeline system would be the most expensive construction project ever undertaken by private industry.

Natural gas moves through pipelines by a process called compression. Gas is composed of rapidly moving, independent molecules. At average room temperature and pressure, the space between these molecules is about 1,000 times the diameter of each molecule. Large pumps called compressors are used to increase the pressure on the gas, forcing the molecules closer together. The gas moves away from areas



Valves in a compressor station.

Engineers check deliveries to a pipeline construction site.

of high pressure near the compressor stations to an area of lower pressure down the line. Eventually, it reaches another compressor station and the process continues.

Natural gas travels of a speed of about 15 miles an hour in transmission lines. The compressor stations are located every 50 to 100 miles along the line to maintain this rate. A computerized dispatch center manages and operates these compressors, often by remote control. When the pipeline reaches a major population area it runs into a facility called a city gate. This is operated by the local distribution company. Here the gas pressure is reduced and the gas is fed into distribution pipes.

Natural gas has no color or odor. As a safety precaution, the gas is mixed with an odorant. By adding this safe but distinctive odor (usually similar to that of rotten eggs), gas leaks can be detected and corrected.

The distribution company delivers gas from the city gate to users through smaller underground pipes called mains and services. Mains are 6 to 12 inches in diameter and carry the gas at about one-half pound per square inch pressure. Services bring the gas from the mains to the individual gas meter. Services are less that 2 inches in diameter and operate at very low pressure. The gas meter measures the volume of gas a consumer uses. The meter reading is the basis for billing from the local gas company.

Consumer demand for natural gas changes with the seasons. Because home heating involves a large use of gas, the winter months generate more demand for gas than do the summer months.

LNG: LIQUEFIED GAS

Moving natural gas by pipeline is an efficient way of transporting it. But where no pipelines exist, such as across oceans, there still is the potential for transportation of gas.

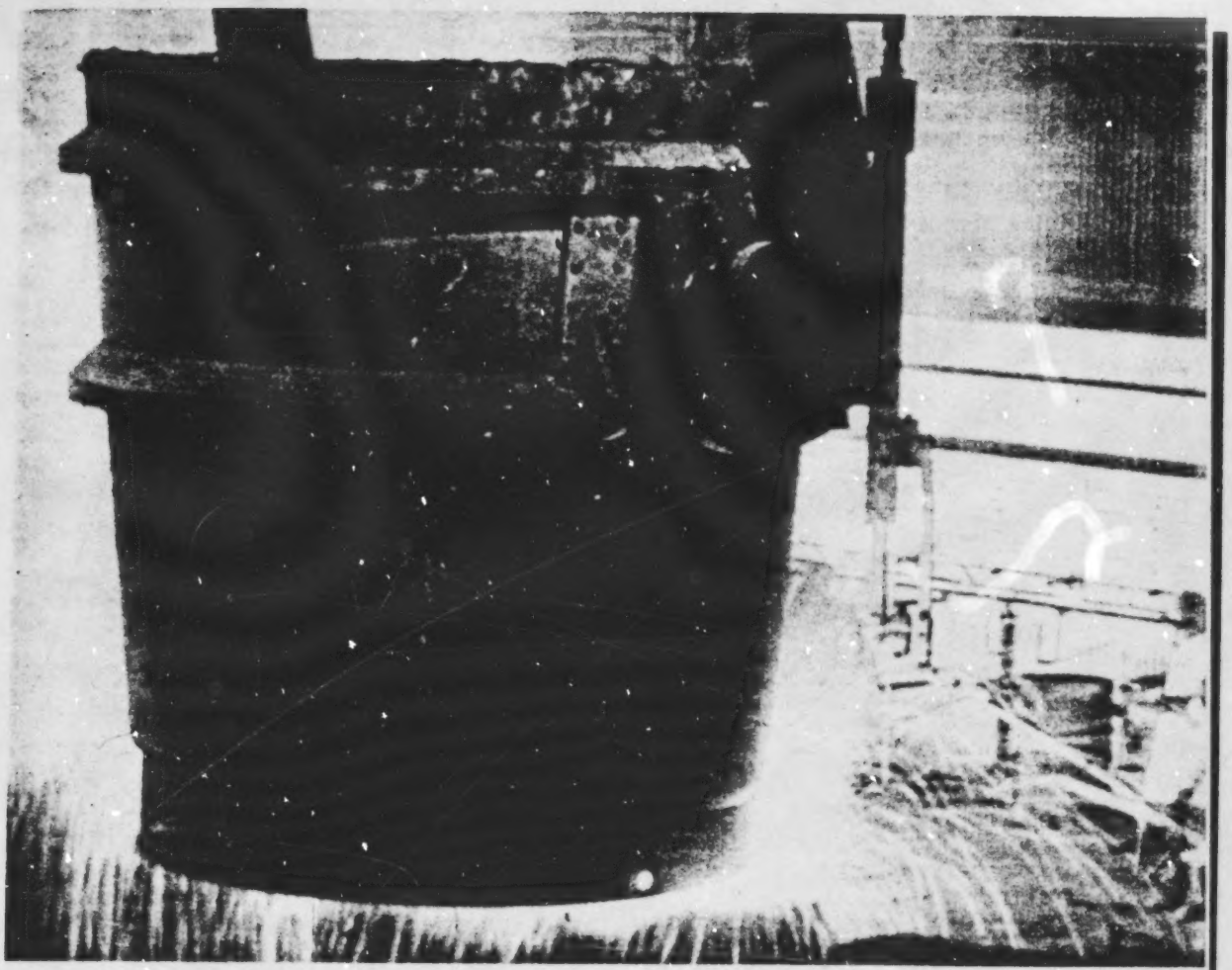
By dropping the temperature of natural gas to −161 degrees C. (−260 degrees F.), the gas is changed to liquid form and its volume is reduced by 615 times. (If you reduced a car by 615 times, you could fit it on your thumbnail.)

This liquid, called liquefied natural gas (LNG), can then be efficiently transported in specially designed insulated tanker ships. One of these ships can carry enough LNG to meet the annual heating needs of over 18,000 families. LNG also can be transported in insulated tank trucks.

Equally important, LNG provides a convenient way to store natural gas. Large quantities of gas can be held in a liquid form in insulated tanks and then warmed back into a gaseous state and reinjected into the pipeline system when gas demand is greatest.

Rather than design pipeline systems to meet the maximum demand for gas, and therefore work at less than full capacity for most of the year, the gas industry stores gas during the summer for use in the winter.

While some of this gas can be kept in aboveground tanks and in the pipeline itself, the most efficient way to store large quantities of gas is in underground reservoirs. These are often old gas fields that have been emptied by production, or geological formations that held water at one time. The gas is stored until needed and then pumped back into the pipeline system.



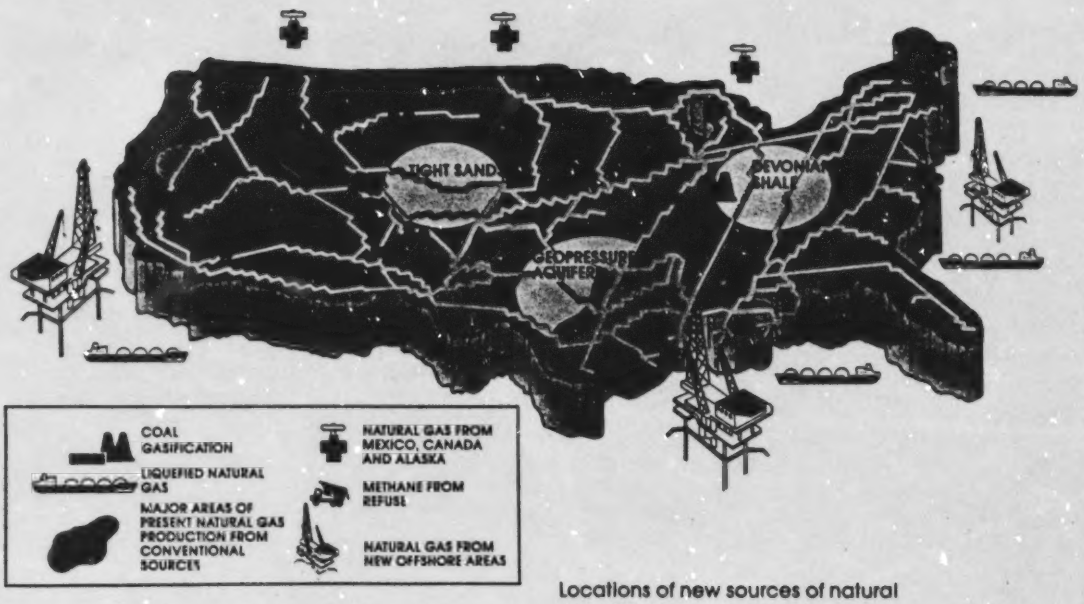
Natural Gas Today

By economic standards, the United States is one of the most successful nations in history. By and large, it provides more of the good things in life to more of its citizens than has any other nation.

The credit for this success rests with many factors. The most important is the personal freedom provided by our political and economic systems. Nearly as important is the extraordinary wealth in natural resources of our land. America's climate and geography have combined to make ours one of the very few countries in history that has always been able to feed its citizens. Our tradition of scientific achievement has enabled us to meet the changing needs of each generation. In addition, our nation has been built upon an abundance of energy. For several generations, much of that energy has been supplied by natural gas.

The chemical energy of natural gas is changed into heat energy when the gas is burned. This heat energy can be converted to other forms of energy — light, motion and electrical — or it can be used directly.

About 40 percent of our natural gas is used in the industrial sector. Gas provides energy to mine minerals, to make the products we use, and to process our food. In addition, the chemicals of natural gas are used as raw materials in combination with other chemicals to produce plastics, fertilizers, paints and clothing fibers.


TIGHT SAND
DEVONIAN SHALE
GEOPRESSURE AQUIFER
COAL GASIFICATION
LIQUEFIED NATURAL GAS
MAJOR AREAS OF PRESENT NATURAL GAS PRODUCTION FROM CONVENTIONAL SOURCES
NATURAL GAS FROM MEXICO, CANADA AND ALASKA
METHANE FROM REFUSE
NATURAL GAS FROM NEW OFFSHORE AREAS

Locations of new sources of natural gas energy.

The chemical industry is today's largest industrial user of natural gas. Iron, steel and aluminum mills, and petroleum refineries also use large amounts of natural gas. So do the glass and ceramics industries, as well as the papermaking and food processing industries.

Many of the products we use come from several different industries. For example, each automobile that comes off an assembly line requires as much natural gas use in the manufacture of its various components as a home uses all year.

The chemicals of natural gas are also part of many of the things we use every day. Orlon, dacron, rayon and nylon clothing fibers are produced using natural gas. Gas is also used to heat the cloth to preshrink it so that it will not shrink later when it is laundered. The ink in this book probably has byproducts of natural gas as part of its chemical composition. So does the film that was used to take the pictures that appear in this book. The mill that made the paper of the book may have used natural gas heat, and the press that printed it probably used natural gas to dry the ink quickly so that it would not smear on the paper. Natural gas has a part in the production of almost everything we use.

Electricity is a secondary source of energy; it must be generated from using a primary energy source. Coal is the principal fuel used for generating electricity, providing about half of our electric power. Natural gas is the second largest energy source for electric generation. About 19 percent of our natural gas is used to make electric power. The main advantage of using gas this way is that gas is a clean fuel that produces only a minimum of emissions. By contrast, coal and oil produce significant amounts of air pollutants, and there are waste disposal problems associated with using nuclear power to generate electricity. Still, because natural gas is more important for use in homes and industry, the federal government has curtailed the building of new natural gas-fired electric plants.

About 12 percent of our natural gas is used in the commercial market. Most of this energy goes to heating and cooling office buildings, apartment buildings and stores. The rest provides the energy for cooking in restaurants. Because natural gas is clean and because its flame is easy to control, it is considered to be a perfect cooking fuel.

The balance of our natural gas — about 25 percent — is used in the residential market, providing heating, cooling, hot water, cooking and clothes drying to 45 million households. The dominant residential use of natural gas is for heating. About 65 percent of the gas used by a home goes to heating. Energy for water heating is the next highest residential use, followed by cooking, and then clothes drying.

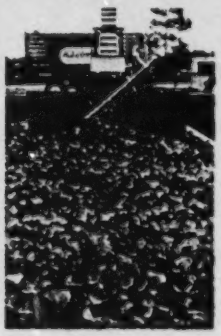
Today, most of the natural gas we use comes from wells drilled in the lower 48 states and off our shoreline. The balance is imported from

HOW A PULSE-FIRED COMBUSTION FURNACE WORKS

1. Air and gas enter the combustion chamber and mix near the igniter.
2. Initial combustion is induced by spark, creating a pressure pulse that closes off the air and gas inlet valve.
3. The pressure pulse forces combustion products down the tailpipe.
4. The resulting pressure drop draws in more air and gas for the next pulse.
5. The in-coming fuel and air mixture is ignited by residual flames and heat from previous combustion cycle. Once started, the process is self-perpetuating.

Water hyacinths are being used to make methane at Disney World.

Divers inspect an underwater kelp farm.



PULSE-COMBUSTION TECHNOLOGY

Development of the pulse-combustion gas furnace is one of the most significant advances in equipment efficiency in years. Its basic concept borrows a technology that was developed nearly 50 years ago as a system to power rockets.

Burning gas in rapid pulses from 60 to 70 times per second in a closed combustion chamber uses fuel more efficiently and reduces the number of working parts in the furnace.

The waste heat of the combustion cycle is pushed by the pulse pressure into an exchange chamber that recovers most of this heat. The pulse pressure also draws more fuel and air into the combustion chamber. Then, the new mixture of fuel and air is ignited by the hot gases remaining from the previous firing.

Canada and Mexico by pipeline, and from North Africa as liquefied natural gas (LNG). Even though we now have adequate supplies of natural gas from these sources, we will need more for the future. Because of this, more attention is being devoted to finding and developing new sources of natural gas.

The first of these new sources is Alaskan. There is a large amount of gas in Alaska, but until the Alaskan natural gas pipeline is built, it will be almost impossible for consumers in the lower 48 states to take advantage of this resource.

Increased importation of natural gas from Canada and Mexico also is important. Both nations are linked by pipeline to the United States and both have supplies of natural gas they are interested in selling. Other nations, not linked by pipeline with the U.S., also have abundant supplies of natural gas and are interested in trading for U.S. goods. The development of liquefied natural gas (LNG) technology has made it possible to import this gas in liquid form in ocean tankers, store the gas as a liquid and then regasify the liquid for use in our pipeline.

We also are intensifying our search for natural gas within our own country. The typical natural gas well is drilled in sedimentary rock less than three miles below the surface. By drilling deeper — sometimes as deep as five miles — and in areas not previously considered potential gas areas, we could find large new gas deposits. New technology also is being used to increase the yield from existing gas wells.

There are two particular types of geological formations which present the promise of a significant amount of gas energy. The first is Devonian shale, a type of rock formed some 400 million years ago. This shale is most prevalent near the Appalachian Mountains and may hold over a 100-year supply of natural gas. The problem is that this gas will be expensive to recover. The shale rock is so tightly compacted that the gas in it flows very slowly, requiring costly drilling techniques to shatter the shale underground and free the trapped gas.

The second is in the tight sand basins near the Rocky Mountains. Here up to a 30-year supply of natural gas is estimated to be trapped in hard, tightly packed sandstone. Here, too, the underground formations would have to be fractured to allow the gas to move to the surface.

The technology also exists to use what may be America's greatest energy resource — coal. U.S. coal reserves are the largest in the world. They represent nearly 90 percent of all our known fossil fuel reserves. That's over 400 billion tons, enough to meet our need for coal for the next 300 years. The problem is that burning coal produces pollution.

Coal also contains a great deal of carbon and some hydrogen, making it a hydrocarbon with the same chemical bases as natural gas and oil. In that fact well may be the answer of how best to use our coal reserves. By adding oxygen and water vapor at an extremely high temperature, the hydrogen and carbon in pulverized coal can be converted into a methane gas. This process is called coal gasification.

Converting coal to a methane gas that can be fed into the pipeline system and used just as natural gas is about 10 times cleaner than burning coal to make electricity.

A similar gasification method can also work with peat, a young coal formed from plant matter decomposing in swamps or under shallow water. The peat resources of Minnesota and Michigan alone have the potential for yielding a 70-year supply of methane. Added to this is a 25-year supply that could be developed from underground coal. Many coal beds contain methane, which is a safety hazard to miners when it accumulates in mine shafts. Drilling methods are being developed that could allow us to recover this valuable gas.

It might be possible that an even larger amount of methane gas — perhaps as much as a 600-year supply—is now sitting one to three miles below the earth's surface along the Gulf of Mexico coast. This gas is dissolved in vast deposits of hot salt water. These areas are called geopressured zones. Results from preliminary test wells support the supply potential predictions, but also reveal problems. The amount of gas in each gallon of salt water is very small, so to recover an adequate amount of methane a large quantity of water would have to be pumped out. There are problems associated with this process. For example, disposal of the salt water after the methane had been extracted presents environmental problems.

An equally large amount of methane might some day be extracted from another source. Methane hydrates are solid, ice-like compounds in which gas molecules are entrapped and bound to water molecules. Russian scientists first discovered extensive methane hydrate deposits in the Siberian permafrost. Now American scientists have collected evidence indicating that there may be thousands of square miles of hydrates beneath the Beaufort Sea north of Alaska, and off the Atlantic coast of North and South America. To date, however, no proven technology exists for recovering this gas.

In addition to these new sources of methane, there are potential sources that are renewable. We could use these renewable sources to recover methane and new sources would replace the ones we have used. Theoretically, these renewable sources could provide an endless supply of methane gas. Quite literally, we would be able to grow our own energy.

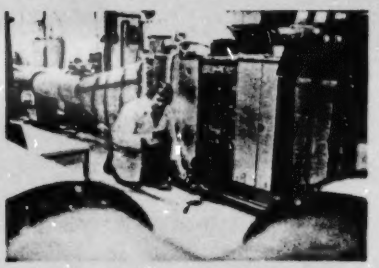
One of these renewable sources is biomass — organic matter, especially plant life, that can be converted into methane gas through decomposition or through digestion by certain types of bacteria. Experiments are now underway to convert sea kelp and other vegetation to methane gas. Off the coast of California a test farm for growing and processing kelp has been operating. Based on the result of that experiment, it is estimated that it would take a kelp farm 300 square miles in area to generate a year's supply of methane for the nation.

The energy resulting from biomass conversion actually comes from the sun. Plants require sunlight for a process called photosynthesis, which is necessary for their growth. Through decomposition or digestion carbon compounds in the plants are consumed by methane-producing bacteria, or combine with hydrogen to form methane.

Methane is also produced from organic waste and in landfills by a similar process. After purification, this methane gas can be fed into the pipeline delivery system. Several cities are currently recovering small amounts of methane from landfills. On the average, each of us each year produces a ton of waste. This waste has to be transported for disposal. Converting some of it to methane gas would help reduce disposal problems.

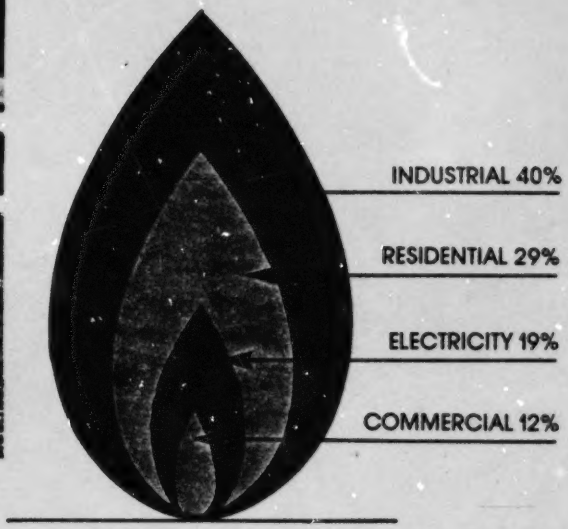
Continuing research and development of these new sources of natural gas are essential to ensure that we will have adequate supplies of gas for the future. Equally important is the work being done to develop new and better ways to use the gas we have.

The natural gas industry has operated a comprehensive research program aimed at improving the efficiency and safety of gas appliances and the gas delivery system. Since 1925 the American Gas Association Laboratories have tested gas furnaces, water heaters, ranges,



Working to improving efficiency of gas appliances and equipment.

City landfills could be tapped to produce methane gas.



clothes dryers, and commercial and industrial equipment. These tests are conducted to ensure compliance with voluntary industry standards of safety, reliability and efficiency. Appliances whose designs meet these standards carry the A.G.A. Blue Star seal.

The Institute of Gas Technology is one of the major basic research organizations for the gas industry. Its 400 scientists study all phases of industry operations, from discovering new sources to developing better ways to use gas.

The Gas Research Institute operates research and development programs in supply, equipment design and delivery efficiency. In addition, individual gas companies and appliance manufacturers run research programs.

Much of this research effort has been directed at improving the efficiency of home appliances. Because about 70 percent of gas use by consumers is for home heating, much of the attention has been focused on developing improved furnaces that generate more heat while using less gas — saving money while conserving our energy resources.

Most older gas furnaces are about 65 percent efficient. That means that only 65 percent of the gas going into the furnace actually goes to heating the house. The other 35 percent is lost in the process. The gas industry has recently developed a new type of furnace called a pulse-combustion furnace that is up to 95 percent efficient. That means that 95 percent of the gas going into it can be converted to useful heat energy. It also means that the amount of gas required for heating a home would be about 30 percent less than that needed with a standard furnace.

MEASURING GAS

Natural gas is usually measured by the volume it takes up at a certain temperature and pressure. The unique property of any gas is that it expands or contracts to fill the volume of its container. By contrast, solids have a definite shape that does not change, regardless of the volume of its container, and liquids will change shape to fit the container, but will not expand or contract.

The standard unit of measurement for a volume of natural gas is the cubic foot — a space one foot high, one foot wide and one foot deep. The amount of gas that would fill such a container at room temperature and at ground-level pressure is referred to as a cubic foot of gas. A cubic foot of natural gas contains about 1,021 Btu of heat energy.

The standard unit of measurement for residential gas use is the therm — 100 cubic feet. Most gas companies now base their meter readings and billings on therms.

A cubic foot is not really much gas. We measure the amount of natural gas used in a home by the thousands of cubic feet (Mcf). We measure the volumes of gas produced in this country each year in the trillions of cubic feet (Tcf). Each Tcf of natural gas contains about 1 quad of energy.

Today, a year's supply of natural gas for this country is about 20 Tcf.

Other research projects are focusing on perfecting a gas-fired heat pump, which can extract the heat in outside air, even at low temperatures, and transfer it inside. Work is also being done to improve the efficiencies of ranges, water heaters and clothes dryers. In fact, new gas appliances already on the market are much more efficient than the same types of appliances sold just a few years ago.

And in the Future

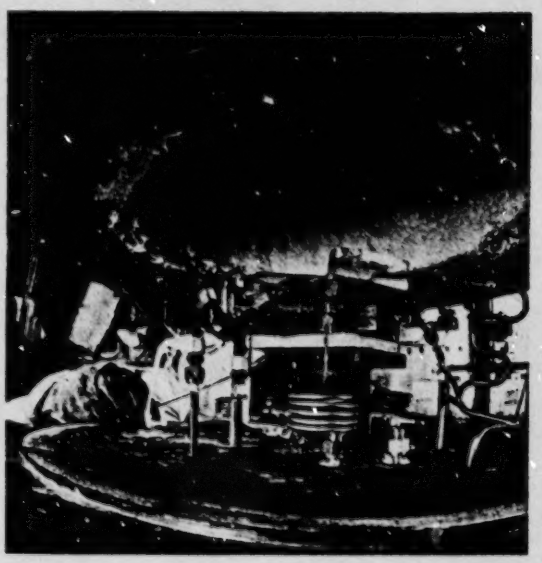
The United States is by far the largest energy user of any nation in the world. We use more energy than the Soviet Union, Japan and the United Kingdom, combined. America uses six times as much energy per person as the world average. With only six percent of the world's population, we consume nearly 30 percent of its energy.

That's not all bad. With only 6 percent of the global population, America produces more than one-fourth of the world's goods, and almost half of its food exports. Our energy use has given us a standard of living unequalled in history. It has fueled the technologies that can split an atom, put a man on the moon, and fashion an artificial hand.

For all its benefits, however, our enormous use of energy has placed a heavy demand on our resources.

America is a nation nurtured on a steady diet of inexpensive energy. Abundant wood and coal fueled our early industrialization at a time when concern for the environment was minimal. Later, cheap domestic oil became the mainstay of our energy mix. Except for a brief period at the end of World War I, the United States had always produced all the energy it used. In fact, we exported oil up through World War II. Following that war, our own demand for oil grew faster than our supply, so we started importing from South America and the Middle East.

Scientists at the Institute of Gas Technology are working to develop an economically feasible gas fuel cell that could generate electricity by a chemical process rather than by combustion.



NATURAL GAS FUEL CELL

A fuel cell is a device for converting the energy content of a fuel, such as natural gas, directly into electricity, through a chemical process rather than by combustion.

Generating electricity by burning fossil fuel is inefficient. The chemical energy of the fuel is converted to heat energy to produce steam. The steam expends energy of motion to turn a turbine. The rotation of the turbine generates the electricity. About 60 percent of the original energy of the fuel is used in this process.

By contrast, a fuel cell can generate electricity in one step. The chemical reaction between the hydrogen of the fuel and the oxygen of air within a solution of potassium hydroxide produces the electric charge.

This chemical process is much more efficient than the combustion process, and it emits no air pollutants. Unfortunately, the technology to produce electricity economically with a fuel cell has not yet been perfected.

By 1972, we were importing about 30 percent of our oil. The next year our entire energy future changed dramatically when the Arab nations imposed an oil embargo and quadrupled oil prices. The era of inexpensive energy was over; there was a new energy reality. Today, despite the problems related to overreliance on foreign oil, we still import much of our oil.

Realizing that energy becomes more expensive as supplies become less available, it makes sense to use energy in the most efficient way possible — using as little energy as we need to do the job we want done and thus reducing our costs and prolonging our supplies. This is the basis of energy conservation. It may be possible to maintain the same standard of production we have today and still use 25 percent less energy. A reduction of that size would eliminate the need to import oil, but it would also cause great changes in our lifestyles.

Less disruptive to our lifestyles, and therefore more probable, would be a program of reducing energy use less drastically, while at the same time increasing our domestic supply of energy. This involves conservation, changing some of our energy use habits, and developing new energy technologies.

As individuals, we have a great deal of responsibility for the way we use energy. Over 40 percent of the energy consumed in this country is for personal use, mostly for our homes and cars. That means that each of us has the ability to personally effect savings in money and energy.

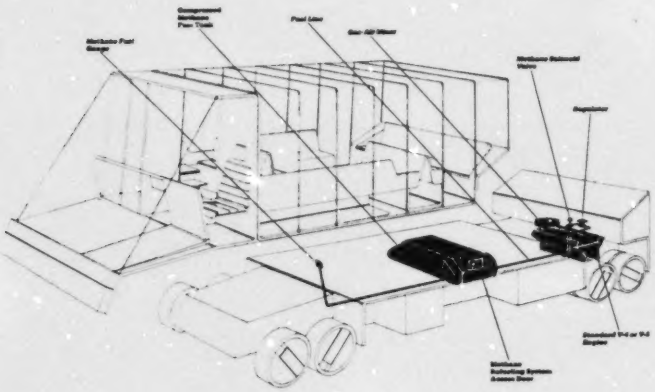
At home, keeping the furnace set at 68 degrees in winter, and the air conditioner set at 78 degrees in summer, conserves the most. On a national average, you can save about 3 percent in fuel costs for every degree you lower the thermostat in winter or raise it in summer.

Insulating a house, caulking around windows, installing storm windows and doors, and weatherstripping can cut heat loss by 30 percent. Because heating fuel used to be inexpensive, it was cheaper to use more heat than to insulate. As a result, nearly half of the homes in the country are underinsulated. With rising fuel prices, it now pays to insulate.

Maintaining household appliances and equipment seems like a small thing, but it can result in large savings. For example, a faucet leaking hot water at a rate of one drop per second will waste over seven gallons in a 24-hour period, or 2,555 gallons a year. Lowering hot water temperature to 140 degrees, insulating hot water heaters, and running full loads in washing machines and dishwashers will save energy. So will making sure your refrigerator door is sealed properly.

Additional energy savings at home can be achieved by replacing older appliances with new ones that are more efficient.

On the road, driving lighter cars with smaller engines, and driving slower will conserve gaso-



NATURAL GAS-POWERED VEHICLES

Natural gas already is an important energy source for homes, businesses and industry. Someday it may become an important transportation fuel as well.

The technology now exists for running cars and light trucks on natural gas. Here, gas can be burned in a regular internal combustion engine that is fitted with a special carburator and natural gas tanks. The natural gas is either compressed in the tanks or is in the form of liquefied natural gas that vaporizes when it is released.

There are several advantages to running cars on natural gas. The fuel is abundant, it costs less than gasoline, it has a higher octane rating, and it burns cleaner.

Today there are about 20,000 cars in America running on natural gas.

line. Keeping a car's engine tuned will save up to 20 percent at the gas pump. These conservation measures can be extremely important in reducing oil imports because much of our gasoline is produced from foreign oil.

The most significant cost savings in transportation comes with carpooling and using public transportation. Carpooling could save America 33 million gallons of gasoline each day. Using buses, trains and subways instead of private cars could save every working commuter up to $1,000 a year.

On average, everyone in this country disposes of a ton of waste each year. Much of this waste results from the packaging of products we purchase, and producing that packaging requires money and energy. Consider a can of peas — it takes more energy to make the can than to grow the peas that are inside. Changing purchasing habits, and recycling such valuable resources as aluminum cans, paper and glass will save huge amounts of energy.

On the job, systems designed to utilize the exhaust heat from manufacturing equipment to heat factory space has saved millions of dollars in energy costs. Higher energy costs in manufacturing have prompted industry to look for better ways to make things with less energy. This has resulted in a 30 percent reduction in energy use in many industries since the mid-1970s.

As important as using less energy, is using the correct energy source for the job. We use oil to make gasoline for transportation. Coal is burned primarily to make electricity. Natural gas is the main energy source for manufacturing and for homes. Each energy source provides certain advantages that make it appropriate for a particular use.

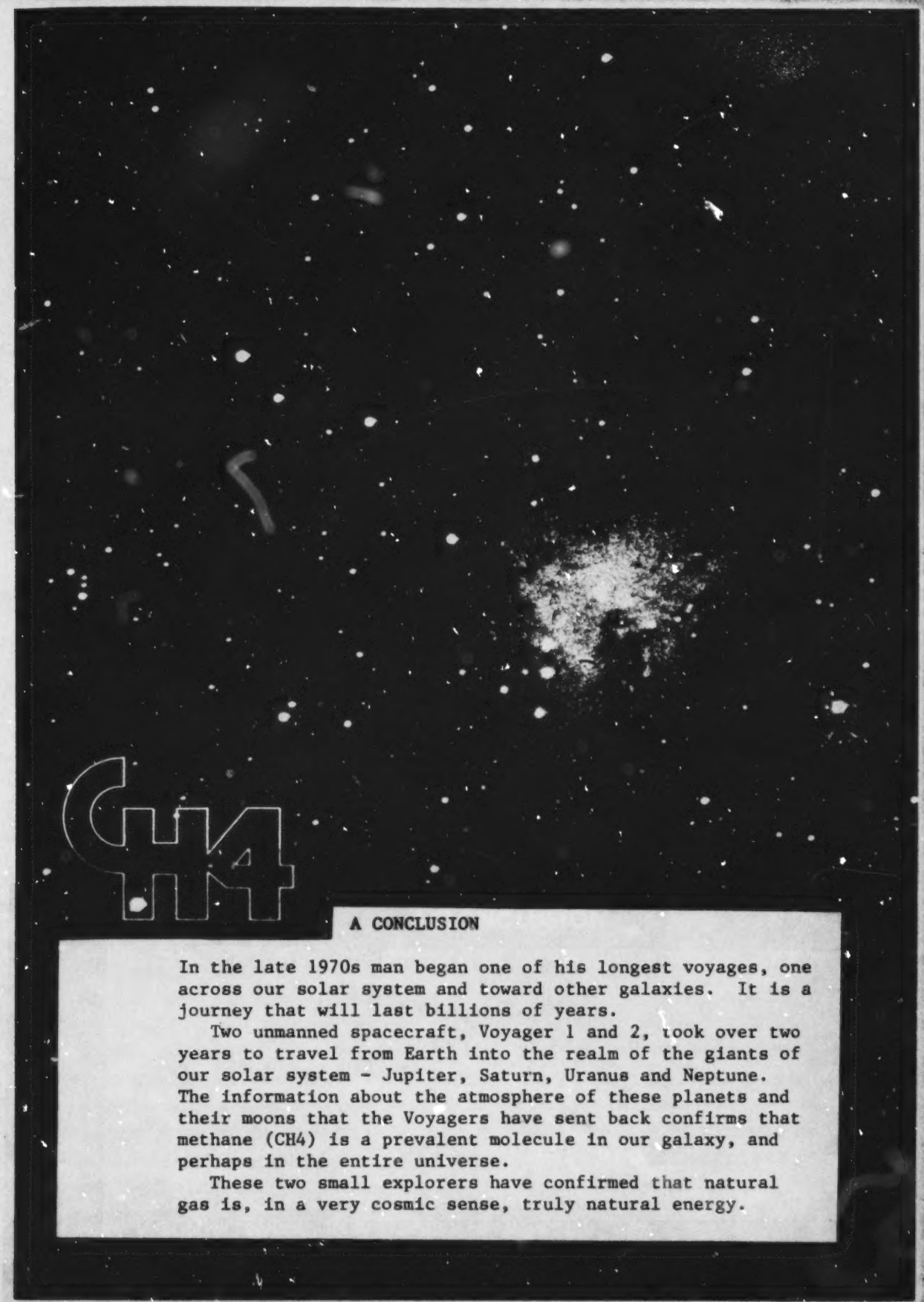
For some time to come, gasoline will be the most popular fuel for running cars. This is because the technology already exists for cars to operate on gasoline, and because we have a nationwide system of service stations to deliver the gasoline directly to users.

Coal is best used in large, centralized locations, such as power plants, where its pollutants can be controlled. The coal can be converted into electricity, which is the best way to provide energy for lighting and many appliances.

Natural gas is an efficient source of heat energy. By weight, it produces 50 percent more heat energy than coal, and 30 percent more than oil. We also have an effective system for transporting and storing natural gas. Equally important are the environmental advantages to natural gas use. Drilling for gas can coexist with open space; pipelines and storage fields are underground; methane gas can be made from less environmentally acceptable materials, such as coal and trash.

Natural gas is our cleanest-burning fossil fuel. When it burns, its primary products are water vapor and carbon dioxide. Traces of other chemicals, such as nitrogen, also are released, but in significantly smaller quantities than when coal or oil is burned. Because of the relative cleanliness of natural gas use, we don't have to make a trade-off between energy and a clean environment. We can have both.

Reducing overall energy consumpton, choosing the most appropriate energy source for the job, and protecting the environment are all important considerations in our energy future. So, too, is the need to continue developing new technologies to use natural gas more efficiently, and to use it in the place of other fuels, especially imported oil.



A CONCLUSION

In the late 1970s man began one of his longest voyages, one across our solar system and toward other galaxies. It is a journey that will last billions of years.

Two unmanned spacecraft, Voyager 1 and 2, took over two years to travel from Earth into the realm of the giants of our solar system - Jupiter, Saturn, Uranus and Neptune. The information about the atmosphere of these planets and their moons that the Voyagers have sent back confirms that methane (CH_4) is a prevalent molecule in our galaxy, and perhaps in the entire universe.

These two small explorers have confirmed that natural gas is, in a very cosmic sense, truly natural energy.

Natural Gas Energy
was written and produced by the JN Company for the Educational Programs Division of the American Gas Association.

Additional copies of this booklet and other information about natural gas are available by contacting:

Educational Programs
American Gas Association
1515 Wilson Boulevard
Arlington, VA 22209

American Gas Association

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NATURAL GAS ENERGY

1. At what grade level did you use this kit?

   ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 Other _____

2. Which disciplines are best suited for use of these materials?

   ☐ Earth Science ☐ Social Studies

   ☐ General Science ☐ Career Guidance

   ☐ Business ☐ Other _____

3. On a scale of 1 through 10, please circle your evaluation of the total package

   Poor 1 2 3 4 5 6 7 8 9 10 Excellent

   Please explain _____

   _____

   _____

4. Please circle your evaluation of the booklet.

   Poor 1 2 3 4 5 6 7 8 9 10 Excellent

   Please explain _____

   _____

5. How much discussion time did you devote to this program?

   _____

6. Which element did you and your students find most valuable?

   _____

7. What changes would you like to see incorporated into this program?

   _____

   _____

8. What free educational programs would you like to see in the future?

   _____

   _____

9. What additional information or materials relating to gas energy would you find valuable in your classroom?

   _____

   _____

10. Please check each element that you used in your classroom.

    ☐ Booklet ☐ Teacher's Guide

    ☐ Student Projects ☐ Transparencies

    ☐ Wall Poster

11. Approximately how many students participated in this program?

    _____

12. General Comments: _____

    _____

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NATURAL GAS ENERGY

To the educator:

We hope you and your class enjoy using the **Natural Gas Energy** materials. We would appreciate your taking a moment to share your thoughts and comments on the value and content of this program. Your assessment will aid us in creating even more effective educational programs for future use.

We welcome your opinions and ideas, and appreciate your taking the time to complete this questionnaire. When returning your evaluation, just fold the form so our business reply address appears on the outside, and drop it in the mail. No postage is necessary.

Thank you.

Educators' Survey

TWO-PART OVERHEAD TRANSPARENCY SET

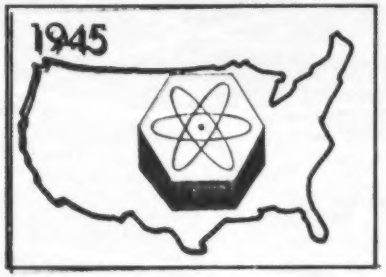
America's Growth

Colonies Declare Independence

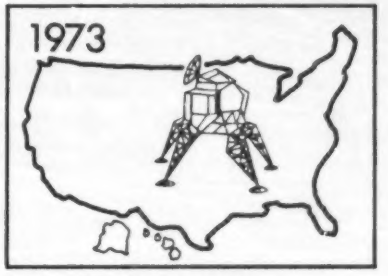
Settlers Move Westward

Railroads Built To West

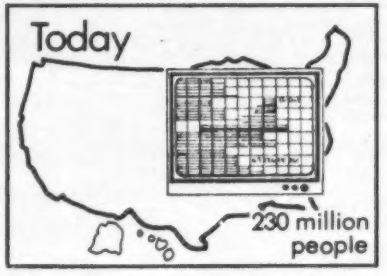
Assembly Line Production



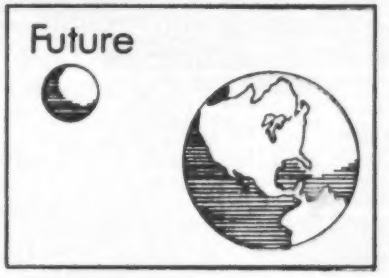
Atomic Age Begins



Technology Fuels Boom



Computers Revolutionize Industry



and Energy Use

Agricultural economy—Small farms and small towns—Animal and human energy—Wood fuel for heat.

Predominantly agricultural economy—Some large factories—Wood provides about 90% of our fuel energy.

Rail and telegraph lines link farms to cities—Population increases rapidly.
Coal is predominant fuel—First oil and natural gas wells—Light bulb invented.

Model T proves efficiency of mass production. Population moves toward large cities.
Coal supplies 80% of our fuel energy—Oil production increases—Gas pipelines layed.

America leads in economic boom—Housing and consumer goods in demand.
Oil is leading fuel and U.S. starts importing oil from Middle East.

Space technology fuels continued prosperity—Population shifted from farms to cities and suburbs.
OPEC declares oil embargo on U.S.—Gasoline lines, higher energy prices.

U.S. remains predominant economic power—Adjusting to higher energy costs.
Fossil fuels and atomic power provide most of our energy—Conservation and developing new energy sources.

U.S. will continue economic and political leadership role—Need to rely upon conservation, efficient use of energy and increased domestic supplies of energy to reduce oil import.